UNIVERSITY OF OSLO

Department of informatics

Mathematics on the tablet: Using mobile technology and gamification to support student learning in junior high

Master thesis

(60 credits)

Andreas Bergli Sætre

11.06.2013

Acknowledgements

My sincerest gratitude goes to my supervisor, Alma Leora Culén, for her guidance and support throughout this project.

I would like to thank the teachers and the students who participation in the case study and experiment.

Lastly, a big thanks to my friends Tania, Eivind and Cristina, which have helped correct the language grammar in this thesis

Abstract

This thesis investigates the role and effect of iPads in an educational environment and the use of gamification to improve motivation and learning in maths classes. The students studied are in Junior High and are between 13-15 years of age.

The research is conducted through a case study and experimental research. A case study of a class which were given five iPad 1s for a semester was used to investigate the role and effect of the iPad. From this study, an application named DragonBox was discovered by the students. The application is an algebra game for tablets, PCs and cell phones.
The experimental research is based on the application found in the case study and is aimed on measuring learning outcome and motivation amongst students. The students of the main class were given five iPads and DragonBox. It was conducted on the same class and a control class over a one month time span.

TABLE OF CONTENTS

Table of figures:

Table of tables:

1 Introduction

1.1 Background:

The content of this thesis may be summarised by its title: *"Mathematics on the tablet: using mobile technology and gamification to support student learning in junior high"*.

Even though the main field of study for the author is human-computer interaction, some familiarity with pedagogy, gamification and education technology was needed in order to conduct the research described in this thesis.

The innovative use of gamification to motivate and drive effective learning is a hot topic despite the scarcity of good examples. An opportunity arose for the author to use the iPad in a junior high school and by serendipity, a now very popular app named "DragonBox" was released during the first study. The first study showed that this application was something the students wanted to get their hands on. This game application was designed for math learning. Math teacher in the class I did my research with used this app. Thus, doing qualitative and experimental research around learning, using the tablet and gamification naturally became the focus of this thesis.

1.2 Goal:

The main aim of the thesis was to investigate how the tablet and gamification influence learning, in particular of mathematics. During the first part of this project, the goal has been to observe how the students use the iPad and its applications. In the second part of the study a controlled experiment was carried out to see if the tablet and DragonBox improve the enjoyment, motivation and learning outcomes.

1.3 Research questions:

1. *Which role and what kind of effect will tablets have in a classroom environment of a junior high?*
2. *Will learning math with help of apps like DragonBox motivate learning for junior high students and improve the learning outcomes?*

The first question was answered through research methods such as observations, logs and interviews with students and their teacher, during the case study. The second question was answered through an experiment in which one class used the iPad and DragonBox to investigate if the application would help improve their results. Another parallel class was used as a control group. The classes were, according to their teachers, comparable to each other. However, the comparability of the classes was not measured as part of this research, and thus the experiment may have some issues with bias, limiting its validity and significance in this research.

1.4 Personal motivation:

The author´s personal motivation for working on this thesis is threefold: the iPad (tablet) technology, games and education.

iPad:

The iPad was considered as disruptive technology for media industry[1] with its ability to break down barriers between different technologies such as cell phones, PC and TV. The question for the author was if it would be a disruptive technology for the classrooms too. Could the iPad change the way learning happens at school? Despite having been around for a two years, the iPads were still considered a cool technology (Culén & Gasparini, 2012) and the supervisor of this thesis offered six iPads to be used in this research. The author lacked some insights to the technology at the time, but thought that the iPad was cool as a learning platform. The author was very happy and grateful for the opportunity to use this technology in this research.

Games:

Games are primarily created to offer entertainment to the user. At least that was the impression at the start of this thesis. The entertainment is the main goal of most games and use many effects to deliver this. Such effects can be relaxation, emotional, political and desire for competition. The author has a long and rich experience with gaming and that made the subject of the thesis more alive and motivating as closer investigation unravelled new aspects and information.

[1] http://rwconnect.esomar.org/2011/03/08/the-ipad-an-industry-game-changer/ (Last consulted 29.05.2013)

One can set many goals with games, depending on the genre and style chosen. However, in this thesis serious games and their effect on learning is the primary focus. A quote from a discussion with a fellow student could be used to explain the educational element often found in these games.

> *Individual games can also teach you more specific things. To use a somewhat macabre example, most 13-year old boys can tell an Ak-47 and an M16A3 apart at a glance because they've spent an extraordinarily long amount of time playing video games that focus on weaponry. Odds are good they can also list magazine capacity, Rate of Fire, and the benefits and drawbacks of a C-mag over a double-mag. [...] Of course, the downside of learning from video and computer games is that games are not primarily designed to educate the user. Historical accuracy and indeed even the laws of nature stand second in line to the focus on entertaining the user and creating good gameplay.* (Eivind W.).

The work on this thesis has taught me that games may indeed offer much more than entertainment. It offers something that schools and work places need dearly. Motivation.

Education:

By sheer coincidence, the author happened to work at junior high school. This created an opportunity to approach teachers at the school who were acquaintances and had a friendly attitude towards the technology and the author. Finding a teacher with an interest in technology that also had interest in helping to investigate the role of educational games was not difficult. This meant a lot.

1.5 What separates this research from similar projects?

Similar research has been conducted before and will be conducted in the future. In the current situation most of the previous research is limited to only education, games or tablets. Some include two of these aspects, such as education and tablets. Some projects have been investigated in the literature review that cover all three, but with many differences such as framework, platform, target group, areas of interest, and many more.

In addition to this, during the literature review, it was discovered that most research found on game based mathematical applications is far from conclusive.

The effects of gamification have been looked at from many angles, and still they offer little conclusive evidence for its effects in educational environments.

Another point that separates this research from most other research seen by the author is that the software used in experiments reported, was constructed for the purpose of the experiment. While this is a strength in many ways, it also may pose a problem, as most such software has bugs. These bugs strongly reduce user experience of the game. In this thesis however, the software has been designed and released for public use. This means that the software has been bug tested, fixed and polished for release. This point could potentially make a difference, as custom-made software can be a very different experience than that of published software.

2 Literature review

The departure point for collecting the literature were some articles and books recommended by the supervisor. These were supplemented by searching different databases such as Google Scholar, PRIMO, BIBSYS, X-port and DUO, listed here in the order of relevance for this work.

Most of the search was conducted by entering key words such as “education”, “iPad + math + education”, “tablet + math” etc. Interesting results were downloaded. Other articles of interest were found listed in the reference lists of the selected papers. As can be seen by the length of the reference list at the end of the thesis, there were not too many articles published in this area.

The sections are structured by different fields contributing to research for the thesis. The iPad as technology (tablets), education, mathematics and gamification were all of importance, as shown in Figure 1.

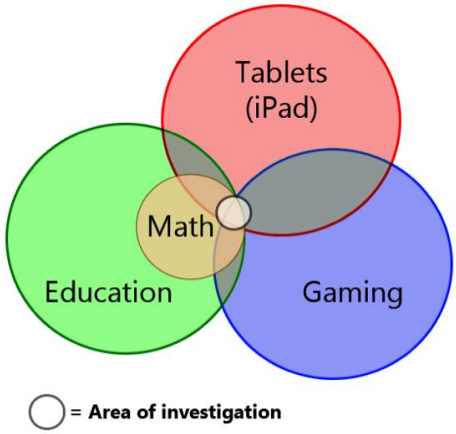


Figure 1. This figure shows the fields covered by the thesis.

Education (pedagogics) is explored first. To the degree possible for one not mastering in pedagogics, the section will provide an overview of educational paradigms. The second section explores the technology adoption in education. The third section investigates the tablet technology in education. A fourth section introduces mathematics to this equation. The sixth section takes a closer look at gamification.

2.1 Education

The purpose of this section is to review, very briefly, approaches to learning, in particular constructivism and the role of collaboration, as it is of relevance for this work.

There are several learning paradigms. The ones found in this thesis are presented as the major learning paradigms by Jung and Orey (Jung & Orey, 2008). These are Behaviourism, Cognitivism, Constructivism and Humanism.

For behaviourism the learning is gained through the environment while the student is passive, therefore the mind is not analysed. The learning visibly affects behaviour, which in turn can be measured. Behaviourism: *"...focuses on a new behavioral pattern being repeated until it becomes automatic"* (Jung & Orey 2008). A response to behaviourism was cognitivism. This paradigm gives the individual an active role in learning and: "*...it focuses on how information is received, organized, stored, and retrieved by the mind*." (Jung & Orey, 2008). Here it is attempted to analyse the mind to understand the processes and structure. The individual must process the information and it is seen in relation to prior knowledge. Constructivism is based on some ideas of cognitivism. The idea of constructivism is that the individual actively interpret information to create their own objective reality. The information is not transferred from someone like a teacher, but rather: *"…based on the premise that we all construct our own perspective of the world, through individual experiences and schema."* (Jung & Orey, 2008).

Constructivism is the paradigm that is believed and followed in this thesis and thus, we shall investigate this closer.

Constructivism

The idea of 'constructivism' is one that has been cited in some of the articles researched in this thesis. It is described by Henderson and Yeow in the following way:

> *Constructivism is based on the idea that knowledge is not a substance that is transferred from teachers to students, but that knowledge is constructed by students themselves when they interact with objects in their environment. [..] the best way to ensure constructive learning is through actively performing a task.* (Henderson & Yeow, 2012)

Constructivism is an approach that could be associated with expressions such as "Learning by doing", or "you live and you learn". The idea is that you spend your time working, researching and experiencing things in order to learn them. Currently, most students are taught with the chalk and talk procedure. This is where the teacher notes facts on the blackboard and relays her information to

the student through speech. There are many researchers who agree with this idea of constructivism. Piaget explains: *"Programmed instruction is indeed conducive to learning, but by no means to inventing, unless, following S. Papert's experiment, the child is made to do the programming himself."* (Piaget, 1973). In addition to Piaget, we have Vosniadou, who suggest that, when speaking about improving learning, students should have *"...hands-on activities, such as experiments, observations, projects, etc."* (Vosniadou, 2001).

Hands on activities, experiments, observations and projects are terms which include a degree of individual study either alone or as a group. From the scenarios this type of work would create the students would have to pursue learning on their own terms, granting them more freedom than during other classes. This would be the freedom of choosing how to engage in activities, and which activities to pursue. However, granting a student too much freedom could have negative effects. Experiences with a younger age group, in elementary school show that:

> *A few years ago the main trend, especially owing to the widespread influence of psychoanalysis, was carefully to avoid frustrating the developing child in any way. This led to an excess of unsupervised liberty which ended in generalized play without much educational benefit. (*Piaget, 1973).

In contrast, examples from more recent studies with students at the age of 18 show that this type of learning situation can be common and valuable:

> *The atmosphere in the class was more like that of a workplace than a classroom. Provided the freedom to wear headphones and walk around to help one another, students were simply expected to do the job they had in front of them and, once they were finished, to move on to another one.* (Peck, Cuban and Kirkpatrick, 2002).

What separates the two examples is the age of the students. Vosniadou explains: "Learning at school requires students to pay attention, to observe, to memorize, to understand, to set goals and to assume responsibility for their own learning." (Vosniadou, 2001) This can be a lot for a child, especially setting goals and assuming responsibility.

The freedom to conduct tasks in the way the students choose means that they can create variation

for themselves in regards to how the material is studied. This strongly opposes the current chalk and talk method. Vosniadou mentions this and explains that situations where students sit and listen for a whole class can be a negative experience (Vosniadou, 2001). In other terms, breaking the built-in habits of teaching as a practice can create variation. This variation would come in many shapes. Hands-on activities, experiments, observations and projects are examples of such (Vosniadou, 2001). What all of these examples could include, is group work. The group work and social interaction seen in the previous quote by Peck et al. (Peck, Cuban and Kirkpatrick, 2002), strongly suggests that this is a positive change. Vosniadou mentions that one should: *"Encourage participation in classroom discussions and other collaborative activities"* (Vosniadou, 2001). This social aspect is further mentioned by Henderson and Yeow, who describe it in the following way; *"social participation is one of the main activities through which learning occurs in children. Children construct knowledge through their interactions and engagements with others, creating shared meanings as they do so."* (Henderson & Yeow, 2012). Being with like-minded individuals who are also in the process of learning can help children. Cooperation between students is meant to better learning. The term "shared meanings" is a way to explain when students work together to create a common understanding.

The main issues brought forth in this section have been; that students learn by actively taking part of their education. Further, they construct knowledge by interacting with objects in their environment. Freedom to pursue knowledge in their own way can also be favoured. Social collaboration is also a positive factor in the learning environment.

The aspects presented in this section will be used in later sections to show the possibility of the iPad in different scenarios. These will also be mentioned in later discussions when augments for and against this technology are presented.

2.2 Education and technology:

Technology has always had slow progress in the educational sector. It is understandable, as it is often the schools that have to adapt– rather than the technology adapting to the schools. In an article by Culén et al. (Culén, Engen, Gasparini & Herstad, 2011), they explain that education: *"...has a history of using new technology not originally intended for educational purposes, and attempting to adjust them to an educational context."* (Culén, Engen, Gasparini & Herstad, 2011).

Interest & use

Some schools see a possibility in technology and this, strive to be some of the first to test this on their students. A closer look at observations done by Peck, Cuban and Kirkpatrick between 1998 and 1999 show us how the technology has been used at some of the most technology-oriented schools. The three researchers spent a whole year observing the use of technology there: "*The two schools we studied are located in Silicon Valley, the world capital of high-tech industry that stretches from San Francisco south to San Jose*." (Peck, Cuban & Kirkpatrick, 2002). The expectations were built up from feedback such as "*Teacher surveys at each school stressed that a few teachers and their students were on the leading edge of technology use."* (Peck, Cuban & Kirkpatrick, 2002). What they found out, was that the technology, though rarely used, served as a supporting tool for education. "*From our shadowing, interviews, and survey data, it is clear that teachers most frequently used technology to support, rather than alter, their existing teacher-centered practices.*" (Peck, Cuban, Kirkpatrick. 2002). The conclusion of this article, regarding this high tech haven, states: "*Despite the dramatically increased presence of information technologies, however, the vast majority of students have school experiences remarkably similar to those of students over the previous 50 years."* (Peck, Cuban & Kirkpatrick, 2002). From this article, the understanding is that despite having the technology, and being able to use this to better learning, it is – if at all used – utilized in such a manner that it functions as a supplementary technology for our current teaching methods. Oleson et al. (Oleson, Surprenant, Carbone and Blair, 2011) explain the evolution seen as: *"Teaching instruction has changed throughout the years from utilizing blackboards, to overhead projectors, and now computers with PowerPoint and non-interactive media."* (Oleson, Surprenant, Carbone and Blair, 2011). In other words, having the technology at hand does not in any way guarantee its full use. The technology we currently see in the schools are only used to strengthen the chalk and talk method. Overhead projectors and normal projectors (computers with power point) are primarily used to show and list points that the teacher discusses with the class. Then again; *"It is only relatively recently that educational technology has been able to support a constructivist approach."* (Henderson & Yeow, 2012).

With all the focus on the technology, it is important to remember just what it can do for education. A speech by Anthony Salcito presented on "learning without frontiers" [4] discuss this

[4] http://www.learningwithoutfrontiers.com/2012/02/anthony-salcito-the-new-classroom-experience/ (Last consulted 28.05.2013)

important aspect of devices and explains that it is not the devices improve learning, but it is the effect they have on the learning environment:

> *I don't know of any devices with magical powers, but fundamentally devices didn't do anything! The students might have been more motivated to learn, the teachers might have been more excited about the experience. The content may have been better, but the students improved learning. Technology served that journey. (*Anthony Salcito, February 21st 2012).

Information technology can be difficult to integrate in classrooms Hank Bromley (Bromley, 1998), offers some insight to how new technology should be adapted by educational institutions. When new technology is introduced in education, the decision is often based on one of two reasons. The first is a clearly planned out process where technology is examined to see if it will fit the goals and vision of schooling "Curriculum-driven", while the other form "technology-driven", is where the people who decide simply want the technology because it exists (Bromley, 1998). Bromley explains that: "*As a result of being a technology-driven initiative, putting computers in public schools has all too often meant getting more of the same, only automated: electronic workbooks, computerized tracking of student "progress"."* (Bromley, 1998). His article investigates what can be done with this and how can we correctly introduce new technology to education. When the new technology is introduced, it is important to consider which baggage comes with this technology. The important aspects he investigates are: who makes the technology, who uses it, and in which context. Bromley asks the following questions about the production: *"What social visions are built into […]? Does it enforce particular forms of pedagogy, or of classroom organization? Does it impose a certain conception of knowledge or of the learning process? Is it compatible only with particular views of what education is for?"* (Bromley, 1998). Whoever made the technology has certain ideas and perceptions of reality which are integrated in the technology. This might have an impact on how the device can be used. Bromley strongly suggest that: "*Rather than ask whether a particular use of technology is a good idea, we need to ask "good for whom?". Who benefits (and in what ways), and who doesn't?"* (Bromley, 1998). The purpose of this is to advocate that the institutions strongly consider a technology before it is adapted. There can be many limitations that follow the technology, which can be seen in the product or the classroom situation. The technology might automate some processes, it might not have any effect, or worse, it might hinder positive progress and stop different paradigms of teaching.

2.3 Tablets and education

The tablets

On Apples webpages, we find a short description of what the iPad can offer education. *"iPad inspires creativity and hands-on learning with features you won't find in any other educational tool — on a device that students really want to use. Powerful apps from the App Store like iTunes U and iBooks let students engage with content in interactive ways."* (Apple, 2012). Apple has come a far way in offering tools and services that could support education with the introduction of: *"iTunes U, iBookstore, iBook Author publishing tool and is now marketing interactive multi-touch textbooks."* (Culén & Gasparini, 2012 (2)). Some research has however shown that the browser is the most commonly used tools by students:

> *Both the teacher and the senior teacher say that the web browsing function is the most commonly used and important feature for senior students within the school. It allows students to research topics learnt in class online and is predominately used for subjects such as social studies, science and English.* (Henderson & Yeow, 2012).

Some tools are difficult to grasp and some feel natural to the user. Feedback on the iPad from educational situations has shown that the iPad is easy to grasp: *"Both the senior teacher and the teacher said that the learning curve with the iPad is almost non-existent due to its simplicity"* (Henderson & Yeow, 2012). A more negative aspect can be concluded as Culén et al. states: *"iPad was perceived as a tool that is intuitive and thus would be very easy to take in use. This proved not to be so."* (Culén, Engen, Gasparini & Herstad, 2011). The applications were seen as easy – but not sharing the same origin as the operative system, the assumed intuitive interface disappointed. Culen and Gasparini (Culén & Gasparini, 2011) explain that research on graduate students show they needed help with the use of applications like Dropbox and iAnnotate. They found this difficult, and did not have time to figure this out themselves. A comparative study by the same authors (Culén & Gasparini, 2011) with younger children, explain that: *"The children, on the other hand, were not under time or academic pressure. They were interested in exploring and found it not to be difficult at all. Thus, for the level of tasks they were performing, they found the iPad to be easy to use, intuitive and playful*." (Culén & Gasparini 2011).

Tablet supported education

There are some schools that are more technologically interested than others, and that are willing to experiment with new technology. The result of this is that some tablets have found their way into the educational environment since the 2010 release of the iPad. In the article "iPad in Education: A case study of iPad adoption and use in a primary school" by Sarah Henderson and Jeff Yeow (Henderson & Yeow, 2012), they conducted a case study with a New Zealand primary school with students of aged 5-12. Other studies like "Children´s journey with iPads in the classroom" by Gasparini and Culén (Gasparini & Culén. 2011) look into effects of learning with iPads for 4th graders (age 8-9 years of age).

These studies investigate the iPad phenomenon in the classrooms. This includes how they are received and used. The difference between these studies, other than the slight difference in age of the students, is that one school was very technologically interested. The school in New Zealand already offered netbooks for their students to use and had Wi-Fi available for all. This stands in contrast with the Norwegian school example, which had smart-boards and stationary PCs for the students available, but justified the participation of the study with the interest of having the curriculum available for all students (current shortage of books). They did not have Wi-Fi at the time of study either, which can be seen as quite a challenge when dealing with iPads, because of the net-use cost (price of 3g mobile network). It is an interesting starting point. One school is dedicated in using this technology for the sake of the technology itself, with a lot of previous experience in the field. The other school has some technology that is rarely used, and a teacher that does not really show signs of interest in this device.

Let us first start with how the experiments ended. The New Zealand project ended in great success, and iPads were bought for the whole school. They were in possession of 48 iPads when the article was published, and are very satisfied with their investment. They state that: "…*students felt engagement and felt empowered by their work. [...] Use of the iPad often resulted in students spending more time and effort on their work.*" (Henderson & Yeow, 2012). A positive and encouraging experience, which increased motivation and signs of individual learning.

The Norwegian project had a fairly similar outcome. A quote from the article states; *"We have observed, as well as heard from the families, students and the teacher that iPad has enhanced both teaching and learning. Students were more immersed in their reading and creative activities."* (Gasparini & Culén, 2011). Further research from other sources can confirm these findings. Research by Stickel (Stickel, 2009), show positive results in motivation and enjoyment of classes by the use of tablets. In addition, the research shows that it: "*... is clear that the tablet PC offers*

many advantages over the traditional blackboard approach to improve the overall learning experience of the students. It enables the instructor to engage the students more thoroughly through the use of added multimedia content." (Stickel, 2009). In an article written by Koile, Reider, and Rubin (Koile, Reider, & Rubin, 2010), we find research conducted with upper elementary school and middle school students. They explain:

> *Overall, students seemed very engaged [...]. The drawing component provided an alternative input to handwriting or typing, and proved popular and successful with all kinds of students, especially those in the lower academic sector. Student sharing of work provided a classroom context that invited discussion and student-led explanations. Teachers were unanimously enthusiastic about using and developing lessons specifically for the tablets*. (Koile, Reider, & Rubin, 2010).

In this case, variation, social collaboration and motivation stand out strongly. The social collaboration has also been confirmed by other studies which show that: *"A total of 76% of the students in the current study agreed (agree or strongly agree) that the TPC (tablet pc) helped them interact with other students, although only 42% thought it helped them interact with their teachers."* (Sommerich et al, 2007). In other words, the tablet devices is well designed for social collaboration, which is strengthened by the shape and size of the tablet: *"Smaller devices are better able to facilitate social collaboration than PCs which users must use singly [...]"* (Henderson & Yeow, 2012). In addition to the social collaboration, research show that: *"…the tablet PC had the greatest impact on learning outcomes that involved higher order thinking skills, basic academic skills or discipline-specific skills."*(Millinder, 2007). Thinking skills and academic skills can be linked to motivation. The motivational aspect affects the general attitude amongst students towards learning and can be a powerful tool to entice the students. Sommerich et al. have researched the general attitude amongst students (in relation to tablet technology) at a high school level, and found: "*The responses to these questions reflect the generally positive attitude of the students towards the TPCs (tablet pc). For eight of the ten questions on positive impact on school, 70% or more of the respondents either responded 'agree' or 'strongly agree'."* (Sommerich et al, 2007). Other statistics by Stickel from tablet enhanced education show us *"…with 90% of the students indicating that they were "helpful". As well, the vast majority (81%) of the students clearly stated that they found the TPC-based lectures more enjoyable than the blackboard-based lectures."* (Stickel, 2009).

Negative aspects

Despite the promising results from these articles, there are some negative. According to Ben Wieder (Wieder, 2011): "…*early studies indicate that these finger-based tablets are passive devices that have limited use in higher education."* (Wieder, 2011). Wieder further contributes with experiences from similar projects and explains:

> *Mr. Steinhaus and other administrators soon realized that the iPad, with the slow finger-typing it requires, actually makes written course work more difficult, and that the devices wouldn't run all of the university's applications [...] I'd hate to charge students and have them only be able to use it for e-mail and Facebook.* (Wieder, 2011)

This aspect has also been explored by Culén, et al (Culén, Engen, Gasparini & Herstad, 2011), which reached a similar conclusion. They discovered further troublesome issues regarding the physical environment (lack of wireless networks in their homes, classrooms not optimal for iPad use), consumption / production and communication between the iPads and other types of technology (Culén, Engen, Gasparini & Herstad, 2011). This article investigates some of these, and asks how the students take their notes during lectures. What they find is that: *"... only four students answered iPad, while 23 stated that they use paper. One student was using laptop and 3 said that they do not take notes*." (Culén, Engen, Gasparini & Herstad, 2011). Partly contradictory research by Stickel (Stickel, 2009) indicates 58% of students are happy with taking notes on the tablet. Further issues were that the students did not take the time needed to learn the device. They simply claimed they did not have time, and explained a severe lack of motivation, since the device was not theirs to keep. (Culén, Engen, Gasparini & Herstad, 2011).

Motivation and production of information were the two major points in this criticism. Earlier we saw that motivation was one of the main positive aspects from the research. From this we can gather that if the students are motivated to understand and use the device then success is highly likely. If the opposite is true then the device might rarely be used.

The issue regarding consumption and production has not so far been looked at thus far. The iPad is not constructed with too high ideals for production in mind:

> *One issue brought up by the senior teacher is that they are aware that the iPad is a difficult tool to be used for creating content but easy to consume, due to the nature of it. However, it was made apparent by the senior teacher that the iPad should not be used as an exclusive tool in education but to be used alongside others*. (Henderson & Yeow, 2012).

Silva and Rocha (Silva & Rocha, 2012) investigate the production aspects of tablet thoroughly and uncover many problems with tablets as input devices. Other issues have been reported, which do not relate to the production aspect. These issues can be seen as flaws with the current state of the device. The study from New Zealand had some negative feedback regarding the device: *"The mobility is perhaps a mixed blessing when it comes to collaboration. The collaboration benefits of the iPad do not seem to be as strong as might initially be suspected and this is partly because of the mobility and partly because of the multi-touch."* (Henderson & Yeow, 2012). The issue was that, despite it being viewed by many at the same time, only one person can sit and use the touch functionality. This limitation presents a possibly problematic aspect for social collaboration. More negative experiences are had however, as it does not end there. The next example comes from an experiment conducted at a high school.

> *For the most part, students reported experiencing TPC problems infrequently ('rarely' or 'never'). One exception to that was Question 14, to which about 30% of the students reported batteries dying during school frequently ('most of the time' or 'all the time'). Another problem was the inability of a sizeable percentage of the students to find documents on the TPC; 39% of the students could find documents on the TPC 'rarely' or 'never' (Q22).* (Sommerich et al, 2007).

In addition, this article promotes another phenomenon, where it questions the teachers ability to actually integrate the tablet in their classes: *"A total of 33% of students at least agreed, but 46% were neutral and 21% disagreed to some extent that their teachers know how to integrate the TPC into their classes."* (Sommerich et al, 2007).

There is also something called the Novelty effect. Novelty-effect (or cool factor) is referred to in Culén & Gasparini, 2012(both) / Henderson & Yeow, 2012 / Fister & McCarthy, 2008. This is the phenomenon where the students are motivated for use when they are first acquainted with the new device due to coolness of possessing the technology. Later however, the students lose interest as the

novelty effect wears off and they are accustomed to the device. Research by Henderson and Yeow explain that the results from this effect varies. In their research, when the novelty effect wore off, it did not reduce the engagement the students had with the tablet. (Henderson & Yeow, 2012).

What we see from these negative experiences, is that the device has strong limitations, and so do the students that use them. The research done on younger students avoid issues with motivation and rather explains that it is one of the major benefits. In addition to problems with devices and students, there are also issues with the teachers, and the classrooms. From this research we see that all parts involved can experience problems, but that in most cases the students are happy with the situation. In addition to this, there were no studies found with purely negative findings.

2.4 Tablets in a Math education

Mathematics is a field where the technological progress has been limited. With the complex mathematical equations required devices need advanced functionalities. This is often more than a keyboard can offer, and from personal experiences with attempting to write an equation with a keyboard, it is hard work. This is demonstrated in a research paper by Peck, Cuban & Kirkpatrick (Peck, Cuban & Kirkpatrick, 2002). Here we are presented with a grim reality: *"…in school wide student surveys we conducted, students reported a modicum of computer use in English and social studies, but negligible to absolutely no use in math, science, and foreign language.",* but further explain: *"they did mention that many instructors occasionally used VCRs (and, in math, graphing calculators) and frequently used overhead projectors"* (Peck, Cuban & Kirkpatrick, 2002).
This research was conducted ten years ago and therefore might be subject to some change. However as the previous articles have shown, more technology does not necessarily change anything. The quote mentions one instrument used in mathematics, and that is graphing calculators. The special made calculators that the schools still use, cost around 100-200 dollars, and are in most cases required to participate in mathematics classes of junior to senior high and above.(subject to change, as this is the case in Norwegian school). Oleson, Surprenant, Carbone and Blair explain the following about the mathematical situation:

> *Schools and educators continue to explore new technology-based techniques and tools to enhance student education. However, within the subject area of mathematics, and specifically algebra, traditional methods of instruction such as using graphing paper and blackboards are still heavily relied upon*. (Oleson, ASurprenant, Carbone & Blair, 2011).

A problem discovered when looking in to this topic, is finding relevant research for students around 13-16 years of age. Most of the research discovered, covers university / college level students with their mathematics. However due to the nature of mathematics, one can argue that though more advanced, the equations are comparable and the same tools can be used to calculate the equations.

Related research

The first example of research done in this area is by Fister and McCarthy (Fister & McCarthy, 2008). In their article "Mathematics instruction and the tablet PC", they attempted to use a tablet for mathematics courses. Programs like "Virtual TI" and "Math journal" were used on the tablets with an input method using "*the power of the pen*" (Fister & McCarthy, 2008). That expression means the tablets they used for the project could use a stylus to directly input equations on the tablet. The issues they experienced were not too surprising, and the applications had issues recognizing certain signs and letters. There were major advantages, as one could connect the tablet through wireless to a projector and let the student write down equations. This meant the student could show their work to everyone and therefore could discuss more easily with their peers. This is a prime example of engaged and active learning, or social collaboration as previously named in the pedagogics section.

Another experiment, by the same authors, was conducted with a multiple tablet classroom. The students would use "One Note" and "Windows Journal" to create and share notes with each other for class, to solve the equations. There were however issues with this as well, because if work was copied over simultaneously, then one of them would be lost due to communications error.

There are positive findings from the mathematics class where they utilized one tablet for the whole class, the findings from this experiment showed an increase in results by 10-15% compared to the other classes (Fister & McCarthy, 2008) which did not use tablets. A quote from the study show even more impressive results when multiple tablets were used:

> *The benefit of students using tablets to analyse and critique problems was two-fold. First, the students took ownership of their learning. They knew they would have to present their work and they wanted to be mathematically accurate. Second, they were excited to be in class! Upon comparison of exam scores given to this tablet class and to a non-tablet classroom, the scores for an identical exam involving proofs by contradiction, contra*

> *positive, and induction were 16% higher for the tablet classroom. In addition, surveys given indicated that the students felt they had learned the concepts well.* (Fister & McCarthy, 2008).

The quote shows motivation as a strong primary factor of the tablet acceptance. In addition it shows measurable results that are noticeably better than for students without this technology.

Positive results were also reported by Loch (Loch, 2005) and Loch and Donovan, (Loch & Donovan, 2006). Further positive research has been found with experiments conducted on elementary school students: *"Consequently, the statistical analysis of the data collected shows that the technology enhanced group achieved significantly higher mean scores than the control group*." (Kosheleva, Rusch & Ioudina, 2006). The technology enhancement only relates to if they were provided with a tablet or not, as they had the same instructor. This study further explains with the intentions of referring to the earlier segment of hands-on activities: *"Students (internships as teachers) in the treatment group are required to use Tablet PCs to create hands-on activities and virtual manipulatives."* (Kosheleva, Rusch & Ioudina, 2006). In this case they have managed to prove that their technology enhanced education has been fruitful, and they have managed to avoid issues related to the teacher and their knowledge of the device – by making them use and learn it. Aspects of liberty are also found in this literature. An example of this is from Oleson et al (Oleson, Surprenant, Carbone and Blair, 2011). The statement they give is closely related to the aspect of liberty and freedom that we have investigated earlier, and in addition it addresses the issue of motivation:

> *This research suggests that the Tablet PC allows for increased hands-on experimenting, transition from teacher led to student-centered learning, ability to access modern scientific software at an early stage in order to increase motivation, and an improvement in advanced mathematical comprehension and soft skills*. (Oleson, Surprenant, Carbone & Blair, 2011).

This corresponds very well to what we have seen earlier to be a good way of educating the children, and promotes the tablet as something that increases motivation and liberty. Another example is from experiments with students at university level. This relates to the aspects of social collaboration previously explored. Wieder in his article explains:

> *iPads also foster collaboration. Students using them for group assignments in a math class at Pepperdine University were more in sync than were students in a section not using iPads. The iPad-equipped students worked at the same pace as one another and shared their screens to help one another solve tough problems*. (Wieder, 2011).

Further examples are to be found with research conducted on undergraduates from the article by Gorgievski et al (Gorgievski, Stroud, Truxaw & DeFranco, 2005). Despite it not being mentioned, it brings up many aspects of the constructivist learning approach - which mentions motivation, hands-on learning, social collaboration (group work) and liberty (interests). In addition, the situation also benefits the teacher which can be seen here:

> *The results of this study found that students perceived the tablet PC to be an effective and efficient device in delivering the mathematical content discussed in class. Further, students believed that this tool helped to create an active learning environment, to stimulate their interests, and to enhance their learning in a large group lecture format. In addition, the use of the tablet pc helped the instructor cover the required material at a comfortable pace*. (Gorgievski, Stroud, Truxaw & DeFranco, 2005)

There are very clear indications as to the positive contribution this technology can offer. The effects might go up and down depending on different factors, like the novelty-effect(or cool factor of the technology, but one of the things most interesting in regards to this thesis is the continuous reports of the motivation amongst students being greatly increased.
From this section we gather that the field of mathematics and the tablet technology can be very tightly integrated, creating a very different experience in classes and resulting in a positive outcome for both students and teachers alike.

2.5 Gamification

The research we have investigated up to this point has been mostly educational, and so logically are the applications presented in them. There is a “new” phenomenon called gamification. Strictly

speaking, it is not new. It is a term that lately has been increasingly used and is gradually becoming popular. Google is the leading search engine and a quick search with its trend functions show us the situation as depicted in Figure 2. The figure shows frequency of searches since 2009 till today, which countries are the most interested in this phenomenon and lastly the typical search word associated with the gamification term. We see that the term is gradually becoming more popular since late 2010 to 2011 and that social gamification, design and educational gamification are amongst the most frequent inquires.

Figure 2. This figure shows a Google trend search for gamification. Source: Google Trends

A research report written by Meloni and Gruener show that: *"The adoption of applying game mechanics in more non-traditional industries has grown exponentially in the past 18 months. This is due in part to the growth of social and mobile games, as well as the increasing consumer adoption of social media."* (Meloni & Gruener, 2012). According to their numbers, investments in gamification has more than doubled between 2011 and 2012. The authors further point to rising trends: *"...within enterprise, healthcare and educational markets that are starting to come online, further accelerating the market."* (Meloni & Gruener, 2012).
A detailed online trend report on gamification can be found here[5].

To understand gamification it can be helpful to look at some background and statistics for games. A study from the UK (United Kingdom) show that: 32% of the UK population call themselves gamers (Freitas & Liarokapis, 2011). Gaming has often been seen as a male related activity, but 31% of females and 34% for males show surprisingly even shares. (Freitas & Liarokapis, 2011). Other resources also confirm the gender equality (Lung, 2012). 32% is a large amount of the population,

[5] http://www.billchamberlin.com/gamification-a-2013-horizonwatching-trend-report/ (Last consulted 29.05.2013)

and one can wonder in which situation this gaming happens. This gaming is not something that is currently embraced at most work places or in most schools. That means that all of this is actually spare time activity. That people select this to be their spare time activity means that this is something they enjoy. Gamification can offer entertainment as we have seen, but it can offer so much more. In an attempt to promote the best sides of gamification for education, Saunderson (Saunderson, 2011) explain key points that gamification can improve: 1. It can keep the students goal focused with clear expectations and quantifiable goals. 2. It can offer tutorials and immediate feedback on student understanding. 3. Pride is established, as achievements are reached. 4. Learning is adjusted to the student, not the student to the subject. 5. Students can work at their own pace, making teachers mentors or coaches when students are stuck. 6. Students can track their performance, and gives real time results that can motivate them.

Gamification, when referring to tablets their applications, is where aspects from gaming are added in to applications: *"Gamification desires to combine intrinsic motivation with extrinsic one in order to raise motivation and engagement.*" (Muntean, 2011). The primary goal of gamification is not one of learning, but rather the motivation and engagement of the players. Muntean explain in the paper "Raising engagement in e-learning through gamification" that: *"Gamification does not imply creating a game."* and that it *"...makes education more fun and engaging, without undermining its credibility.*" (Muntean, 2011). So far we have seen three goals of gamification, which are raising engagement, making them fun and not undermining credibility. The engagement and fun relates to the users subjective opinion of the game, but the credibility is completely different. It is incredibly important that those who produce these educational applications with gaming elements treat this credibility with respect. If they want to appeal to teachers, it has to be serious and offer credible information and information that is in line with their curriculum. It is incredibly hard to measure the actual impact on learning in the games. From what is found in literature around evaluation of effects, the methodology for this is far from obvious. An article by Harpstead, Myers, and Aleven (Harpstead, Myers, & Aleven, 2013) show many different approaches one can take to analyse the games and their impact on the education. This is meant for game designers and researchers so they can find out what works best in teaching the children and from this improve the credibility of the games.

There has been some effort in creating gamification related terms. Some are familiar with terms

such as “hard and soft” gamification[6], or “structural and content” gamification[7]. The soft and structural form of gamification is associated with adding light gamification elements to content. It includes the game like elements built in to make content more fun and engaging, but keeping the content as the main focus. The hard and content type of gamification are described somewhat differently, but are essentially quite similar. This is where the content takes on a game form as a primary role, while the content presented will be secondary.

Gamification in educational scenarios

A first look at the relevant literature is by Freitas and Liarokapis in their article on “Serious games: A new paradigm for education?”. Here they discuss research that has been done with gamification, and the positive outcome for the users:

> *Two large studies in the UK and US respectively have demonstrated positive results in large sample groups, in one study on Triage Trainer considerable efficacy of game-based approaches over traditional learning techniques were demonstrated (Knight et al., 2010), while in another study on the game Re:Mission behavioural change in children with respect to medication adherence was proven in clinical trials (Kato et al., 2008).*
>
> (Found in Freitas & Liarokapis, 2011)

Further study on children has also yielded positive outcomes. This example has an interesting angle compared to earlier research that show the browser as the most used aspect of the tablet.

> *For the younger children in the school (junior school), gaming applications are used more frequently than the web browser. As the senior teacher describes, children at a younger age are still learning the basics of how to read and write properly, thus making the internet “a bit too high for them”. As a result, gaming applications such as simple math and spelling*

[6] http://blackbeardblog.tumblr.com/post/13452542524/state-of-play-four-types-of-research-gamification (Last consulted 29.05.2013)

[7] http://www.ulqcl.com/kappnotes/index.php/2013/03/two-types-of-gamification/ (Last consulted 29.05.2013)

> *games are more widely used as part of the junior school's learning curriculum.* (Henderson & Yeow, 2012).

From the quote, it is clear that the age of this group plays a significant role in this outcome. Games are in this case being used to help facilitate more advanced learning, and the children are introduced to their topics in a fun and motivating way. In addition, we notice that math is mentioned as one of the subjects effected by this. Looking at another example using mathematical game applications we investigate an article by Oleson et al. (Oleson, Surprenant, Carbone & Blair, 2011). Here they conduct an experiment with an algebra focused game, for the benefits of: *"repetition in a game environment"*. They explain: *"The math being presented is no different than the exercises students currently use but the presentation of the material is what we aim to improve."* (Oleson, Surprenant, Carbone & Blair, 2011). The research did not have any clear outcome in terms of learning, but they explain that *"Demonstrating that the tablet-based games are effective will take much more research but acceptance of the technology by students and teachers are important first steps."* (Oleson, Surprenant, Carbone & Blair, 2011). This partly neutral yet optimistic take, is also shown in research by Polycarpoua et al. (Polycarpoua et al, 2010). The feedback is positive, but presented in a guarded and careful manner: *"The overall feedback from the teachers was positive with most of them indicating that this is something they would like to use as a supplement to their teaching material."* (Polycarpoua et al, 2010). Further positive studies are in the same vague but positive understanding; *"We do have a body of observational material that [...] indicate that the game as a whole works quite well as educational game for learning arithmetic."* (Lindström, Gulz, Haake & Sjödén, 2010). A last semi-neutral example show that the applications are used for reinforcement of learning, but that, the results are fairly inconclusive:

> *Mathematics is the only subject where application games are used by the senior students to help reinforce their learning. However, the senior teacher states that the use of gaming applications (or any application) within the senior school is still a relatively new part of the curriculum which they are still exploring.* (Henderson & Yeow, 2012).

We see from this research that the outcome is positive, but often inconclusive. They present the data in a positively loaded manner but the most we get out of the studies is that the reaction to it has been "positive", but that the results are hard to prove.

The section that discussed pedagogics can yet again have some impact on the research. The first we look at is the idea of freedom or liberty, which we had a closer look at in the section of pedagogics. In research done by Barendregt and Bekker (Barendregt & Bekker, 2011), they show that if presented with freedom in games, it is not always guaranteed that the students will utilize their opportunities:

> *Within the formal setting children in the non free-choice school were rather hesitant to freely choose activities within the game; even when they were allowed to play freely some of them still tended to focus on the task given previously, as is illustrated by what one of the girls writes in her report*. (Barendregt & Bekker, 2011).

From this they speculate that the guidance in these situations can be seen as a beneficial support to learning, based on: *"The most fruitful environment for an educational game like Hello You seems to be within a school system affording considerable freedom, but with a focus on predefined learning activities."* (Barendregt & Bekker, 2011). These findings show that when presented with the freedom of choice, the younger students might not know what to do with it. How the students experience the situation seems greatly reliant on the educational environment. If they are used to making their own choices, then the students are more inclined to follow this thinking in the games. The social collaboration aspect is also visible. Multi-player would be the best suited word for social collaboration in a game environment, but it does rule out certain type of social collaboration. From the article by Barendregt and Bekker (Barendregt & Bekker, 2011), we find that: *"A common suggestion of the children was to the change the game so that it is possible to see other players and talk to them. Implementing this feature could strengthen the group effect once there is a significant number of active players."* (Barendregt & Bekker, 2011). The social collaboration is not only a way to improve the game, but it is also something that students want.

The shadow-side of gamification

The articles investigated up to this point, has shown that gamification is proven somewhat successful in making learning "better". However, some are more sceptical to the current state of gamification than others. Mattew Jensen explains that *"Gamification introduces points, badges, and achievements as intended objects of desire without meaning. It also neglects the power of story and disregards the insights of latent gameplay. To be clear, though, gamification isn't fundamentally wrong – it just needs to evolve past the hype."* (Jensen, 2012). A journalist named Judd Antin

(Antin, 2011) has published some warnings about the trend of gamification. In a magazine article, Antin writes about the psychological motivation behind games, and the general lack of a deeper understanding of this phenomenon. In this article, he writes about the negative aspects of the current trends of gamification.

One aspect of gamification is the point of incentives. This is often in the form of achievements and other small measures which are created to give you positive feedback for performing a task. The writer ponders if the short term "shallow" incentives and rewards might have a negative effect for people in the long run. Examples like wiki-editors are used, and he lists their current motivation in "*…shared investment in activities, interests and beliefs that form a genuine connection among community members.*" (Antin, 2011). These community driven forums thrive from the social collaboration that is found in them, and incentives for these programmers are mostly based on their reputation and position when constructing the software.

This is a cautionary tale of the issues which might arise if gamification becomes a thing, and the current unpaid community driven sites might one day be in trouble. He explains that:

> *Game mechanics are, without a doubt, already effective motivators for some people in some contexts. Question-and-answer sites like Yahoo Answers successfully introduced points and badges long before the current craze. Well-designed incentive systems can enhance collaboration and bring more voices to the conversation. But game mechanics are not the magic potion they're made out to be. Gamification is still in its infancy, and much more research and development is needed to deliver its valuable potential.*
> (Antin, 2011)

This short article is an attempt at a wake-up call for buzzwords like gamification. There can definitely be future issues from the evolution of gamification.

Another author that questions this trend of gamification is Chun Fei Lung (Lung, 2012). He questions is we overestimate the capabilities behind gamification. The author questions the possible areas of application, and refers to Gartner hype cycle for emerging technologies[8], see Figure 3.

[8] http://www.gartner.com/DisplayDocument?doc_cd=233931 (Last consulted: 29.05.2013)

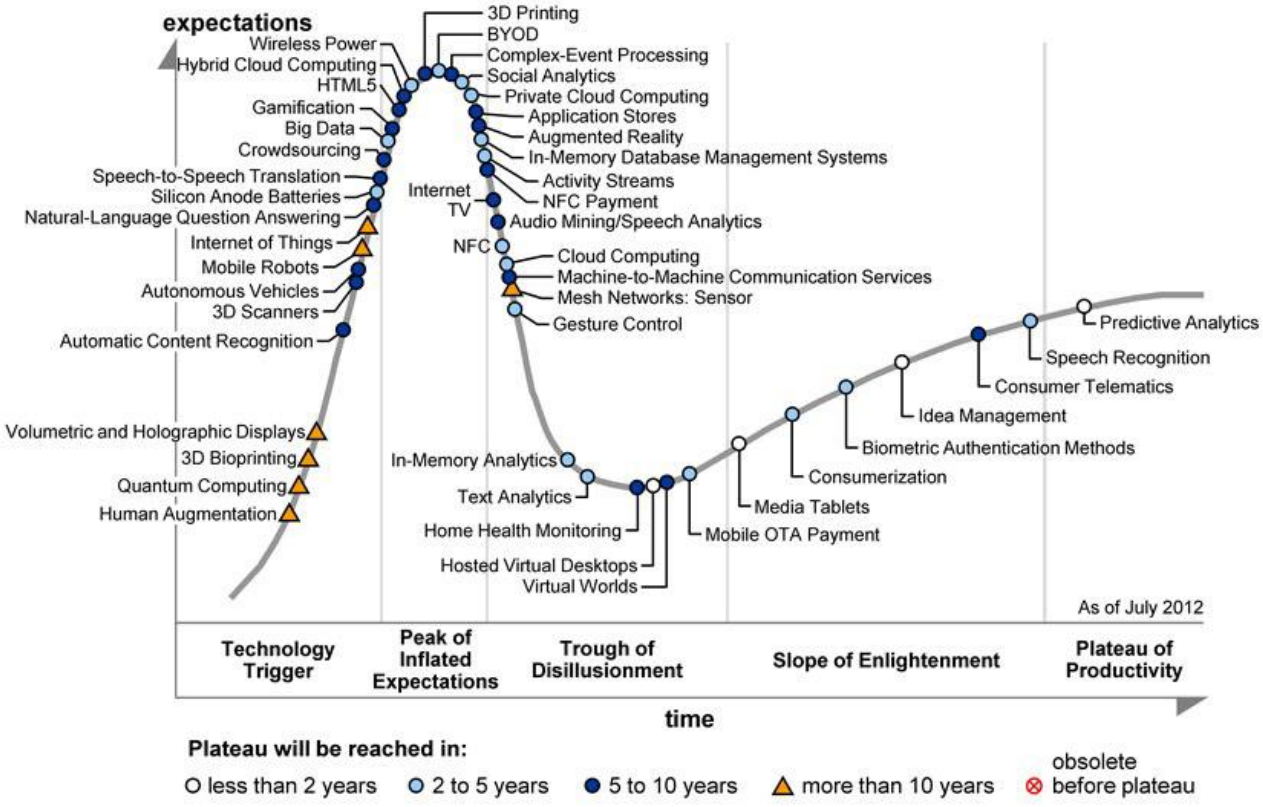


Figure 3. The figure shows Gartner hype cycle for emerging technologies. Source: Garner

The author explain that what we see in this figure *"...could be an indication that the benefits of gamification and serious games currently are vastly overestimated, and that the bubble created by the hype surrounding it will soon be burst"* (Lung, 2012). In strong relations to the mathematic subject which is investigated in the experimental research, Lung shows to the lack of conclusive evidence previously mentioned and explains that: *"...serious games were found to have an effect in the areas of language learning, history and physical education. On the other hand, no positive effects were found in areas which require logical thinking, such as science and mathematics*." (Lung, 2012). Still on the topics of maths, Lung refers to research done in Brazil showing that the participants: *"...are all capable of doing maths for practical purposes, but were not able to apply those same mathematical concepts on paper-and-pencil tests*." (Lung, 2012). The issue presented is related to math and other educational games and shows that the learning does not necessarily transfer from the game to real scenarios. Lung brings forth a worried view which is related to Antin (Antin, 2011). It is a careful approach to gamification, one that looks through the hype and investigates the phenomenon in light of different situations. Neither of these authors have any conclusive evidence, but rather come with a warning towards the trend. Will it make the children

lazy? Will learning with games be so much fun that we cannot do it without? The best answer found is perhaps by Lung, which refers to the internet when it was introduced. It changed everything (disruptive technology), but despite some negative aspects like addition and reduction in social interaction - it changed things for the better (Lung, 2012).

Extreme and awesome examples

There are positive effects and negative. There are worries which have a solid foundation in literature and trends. Sometimes one has to simply jump in to the situation and explore what actually happens. The author of the book "The Multiplayer Classroom", Lee Sheldon (Sheldon, 2011) has done just this. Perhaps better presented under pedagogics, but chosen placed here due to the gaming oriented fundamentals behind the idea. It is unrelated to the tablet technology in itself, though tablets could easily be parts of this ecology. It has been chosen presented here due to the massive focus on gamification elements, inspiration, motivation, and variation, which are seen in all major elements of gamification.The idea is that you do not get grades during the semester corresponding to your immediate performance, because the idea of giving someone and A, then a C which then corresponds to a B is something that does not compute with games. You do not reward someone to simply take it away. It would be like levelling up only to lose levels if you died. The idea behind his experiment was to play through school like an online game such as "World of Warcraft".

Lee Sheldon's Grading Procedure: You will begin on the first day of class as a Level One avatar. Level Twelve is the highest level you can achieve.

Level	XP*	Letter Grade
Level Twelve	1860	A
Level Eleven	1800	A-
Level Ten	1740	B+
Level Nine	1660	B
Level Eight	1600	B-
Level Seven	1540	C+
Level Six	1460	C
Level Five	1400	C-
Level Four	1340	D+
Level Three	1260	D
Level Two	1200	D-
Level One	0	F

Figure 4. This figure shows how the grade system is intended to work in Sheldon's classes.

The case studies in Sheldon's book present different quest situations, where the games and experience they hunt is acquired in different ways. One of the case studies awards "biology bucks" for completing quests in biology. These can be used on things such as hall passes and supplies such as pencils. His project has been a great success amongst the students and he explains that the questing: *"…increases student motivation, student attitude, and student performance. Data proves this fact. Students in my classroom are doing three times the amount of work that students completed in previous years, and they are doing it with joy and without complaint."* (Sheldon, 2011). Further case studies they had gave very positive feedback from the students. Seen as an example of integrating gamification to an extreme, with the purpose of improving motivation and enjoyment of classes, it is incredibly interesting to see this trend taken to a new step.

With all that is new, follows necessary research on the topic to grasp its potential. In this section we have investigated positive aspects and negative aspects of gamification.

We have found that gamification can be a valuable addition to education with motivation as a goal. In addition to this, aspects such as credibility is one of the more determining factors to the possibility of this trend being integrated in every day classes. If one is to add the elements of gamification as a gimmick for sales, then it is likely to have a more negative effect if we are to believe the warning by Antin.

3 Methodology

3.1 General information about the methodology used in this thesis:

This chapter provides short descriptions of the framework and methodology used in this thesis.

A quotation from Myers (Myers, 1997) explain the purpose of this section:

> *All research (whether quantitative or qualitative) is based on some underlying assumptions about what constitutes 'valid' research and which research methods are appropriate. In order to conduct and/or evaluate qualitative research, it is therefore important to know what these (sometimes hidden) assumptions are*. (Myers, 1997)

Myers further talks about three different views of the qualitative research: interpretative, positivists and critical:

Interpretive:

The interpretive approach is one of analysis. In this variant, a phenomenon will be investigated from the viewpoint of people (Myers, 1997). This variant is highly qualitative in nature, and has been called qualitative research by some disciplines.

It was the interpretative framework that was used in this thesis. It was especially significant for the first part of the thesis, which was based on ethnographic work. In addition to Myers's view, work by Nardi (Nardi & O'Day, 1999) on information ecology has been used. Wikipedia defines the information ecology as: *"...the term information ecology marks a connection between ecological ideas with the dynamics and properties of the increasingly dense, complex and important digital informational environment and has been gaining progressively wider acceptance in a growing number of disciplines."*. The "Information ecology" is often used as metaphor, viewing the informational space as an ecosystem. The relations in this ecosystem are still analysed by interpretative methods. Thus, one may say that the combination of the two was the main framework for the thesis.

Positivists:

The positivist version is one that sees the world as something measurable. It is objective. They believe that what is seen and measured, is something that is independent of the researcher. (Myers,

1997). This view focuses on the testing of theories, and has a strong emphasis on quantitative data (Myers, 1997). This means that statistical tools and such become important to this approach.

In the experiment part of the thesis, this is the view that was used.

Critical:

The critical research primarily focuses on social, cultural and political influences. (Myers, 1997). *"The main task of critical research is seen as being one of social critique, whereby the restrictive and alienating conditions of the status quo are brought to light."* (Myers, 1997). This is the critique of society and the focus on all underlying elements that can effect and oppress people, such as political decisions.

Critical view was not used in this thesis.

3.3 Qualitative data

In this thesis, there is a wide range of qualitative data. What falls under qualitative data, is the type of data collected through methods which focus on (usually) few individuals. The purpose of this data is not to get a wide range of input, but rather highly individual and insightful. This data is in the form of their understanding, behaviour, opinions and thoughts. Methods in this thesis that gather qualitative data would be the interviews and observations. The case study will mostly focus on this type of data.

Interviews:

Lazar et al. explains that the main purpose is: "…*to explore a wide range of concerns about a problem and giving interviewees the freedom to provide detailed responses"* (Lazar, Fen & Hochheiser, 2010). According to Crang and Cook (Crang & Cook, 2010), the lines between qualitative data and quantitative data from the interview method are hard to separate. In view of quantitative data, this is a source of unbiased data that is collected and statistically analysed. In view of qualitative data, this method allows "…*the researcher and the researched together construct inter subjective understandings*". The understanding is that either qualitative or quantitative data are both valid options when using the interview method. In addition, one may conduct group or

individual interviews.

Structure

Interview structure can be categorized in to three types:

- Type one is like questionnaires, very tightly structured with predefined questions and lacking detours.
- Type two is the semi structured interviews, which "*Set some broad parameters to a discussion*" (Crang and Cook, 2007).
- Type three is the unstructured variant, which is more like a conversation.

In addition to this, there is a formal and an informal type of interview. The formal interview is one of planning and execution, while the informal type is created through social interaction. The social interaction can be information passed on while conducting observations and similar situations.

In this thesis work, formal and informal variant is used. Tightly structured, semi-structured, and unstructured interviews are used.

Analysis:

Analysing interviews can be done through Content analysis. This approach is suggested in Lazar et al. (Lazar, Fen & Hochheiser, 2010). This method is of the qualitative type, because it tries to make sense of the data in more ways than just using numbers. However, there are quantitative aspects present. These are typically represented in the frequency of occurrences with words, and similar data. The coding process uses either *a priory* or *emergent* form of coding. A priori is the type that is based on the related literature. Emergent is the form where lack of insight advocates custom coding based on the data. In addition to how things are coded, the codes are often different between researchers, as the content is not always easily distinguishable from one category to another. To prevent bias in this manner and keep the data neutral, Lazar et al (Lazar, Fen & Hochheiser, 2010) suggest that there should be more than one coder working on the data. When several coders work on the same analysis, it is important that they reach an agreement as to the use and definition of categories. This is called the intra-coder reliability (Lazar, Fen & Hochheiser, 2010). If the researchers find that they put the data in completely different categories, it is likely that there is a strong individual bias. Kohens kappa is a method used measure reliability between the coders. The formula is given as;

$$K = (Pa-Pc) / (1-Pc)$$

Pa is the “percentage of cases on which the coders agree” (Lazar, Fen & Hochheiser, 2010).
Pc “represents the percentage of agreed cases when the data is coded by chance” (Lazar, Fen & Hochheiser, 2010).
The numbers behind these letters are usually found through an agreement matrix, which is a table that expresses where the coders agree and where they do not. The result of this should be between 0 and 1, where 0 represents all the data being coded by chance, while 1 expresses complete reliability. The tables for these, found in the case study and experimental research chapters, are slightly different than that found in Lazar et al. (Lazar, Fen & Hochheiser, 2010). In this book, the numbers represent percentages of a whole. It was discovered that this could be done without converting the numbers to a percentage, but rather make them represent the number of agreements / disagreements. In both cases, 32 examples were compared. That means 32 is 100% of the cases, which would in Lazar et al. equal 1. Presenting the experiment in this way meant that the agreement matrix was considerably easier to interpret, and all the real values were clearly displayed.

Observations:

Blomberg et al. (Blomberg, Giacomi, Mosher, & Swenton-Wall, 1993) describe the purpose of observations to be: *“...understanding human activity in the every day setting in which it occurs”*. The main reason behind the observatory method, is in Blomberg et al. explained as: “... *what people say and what they do are not the same*”. They further explain that: “*The distinction between what people say and what they do is related to the distinction between ideal and manifest behavior. Ideal behavior is what every" good" member of the community should do, whereas manifest behavior is what people actually do.” (*Blomberg et al, 1993).

- Method one is described by Blomberg et al. (Blomberg et al, 1993) as the “*fly on the wall*” approach. They explain that the researcher should be unobtrusive and stick with the role of observer.
- Method two is the participant observer role. This type of observation requires the researcher to actively take on the same role as the participants, but at the same time being an observer (Blomberg et al, 1993).

It is however noted that these methods can be mixed. This shift can be natural. Blomberg et al. explain that: “*Most often one moves back and forth between participation and observation, variously wearing the hat of the insider and outsider. […] One should not feel bound to choose*

among these observational extremes." (Blomberg et al, 1993).

In this work, both methods are used, but the main focus is the "fly on the wall" approach.

3.4 Quantitative data

Quantitative data is the opposite of qualitative data in many ways. One can still seek a deeper understanding of a phenomenon, but rather than focusing on an individual to achieve insight, one finds truth in numbers. From this one can seek a statistical understanding of a phenomenon. It is typically conducted using statistical tools and methods in these cases, like ANOVA. Methods in this thesis that gather quantitative data would be the information found on the artifacts, logs and results from the tests. The experimental research approach will mostly focus on this type of data.

Archival logs and Artifacts:

An article from Tellis (Tellis, 1997), explains that documentation and records are ways to unobtrusively gain exact information. Artifacts are often used with software such as keyloggers to create logs of the interaction between artifact and human. Weaknesses can be retrievability, biased selectivity, reporting bias and access (also includes privacy).

Statistical analysis:

In Lazar et al. (Lazar, Fen & Hochheiser, 2010), it is suggested that one should run some tests "…*to understand the nature of your data set*". This includes different mathematical expressions, such as; "*Means, medians, modes, variances, standard deviations and ranges*". Comparing these properties can give insight, but this is ill-advised without the help of statistical significance tools:

> *Many studies involve three or more conditions that need to be compared. Due to variances in the data, you should not directly compare the means of the multiple conditions and claim that a difference exists as long as the means are different. Instead you have to use statistical significance tests to evaluate the variances that can be explained by the independent variables and the variances that cannot be explained by them.* (Lazar, Fen & Hochheiser, 2010).

There are three steps of data management advised before analysis. These are presented by Lazar et al. (Lazar, Fen & Hochheiser, 2010).

- Step one: screen the data for possible errors.
- Step two: Coding the data. This is needed if the input contain letters instead of numbers.
- Step three: Organizing the data. This is needed for the statistical tests such as ANOVA.

3.5 Case studies:

In short terms: *"A case study is an in-depth study of a specific instance within a specific real-life context."* (Lazar, Fen & Hochheiser, 2010) To expand on this description, a case study typically focuses on smaller groups (even down to one individual), and on qualitative data (but often includes some quantitative data). The purpose can be described in the following way: *"Close examination of individual cases can be used to build understanding, generate theories and hypotheses, present evidence for the existence of certain behavior, or to provide insight that would otherwise be difficult to gathe*r." (Lazar, Fen & Hochheiser, 2010).

There are a few different variants of case studies described by Lazar et al. (Lazar, Fen & Hochheiser, 2010). These variants are:

- *Intrinsic / Instrumental* (Insights to one event / broader insight of phenomenon)
- *Embedded / Holistic* (Several / one phenomenon of investigation)
- *Single / Multiple case* (One or more case studies. If you have more, the goal is further generalization due to size of research)
- *Informal* (smaller, less rule-bound study with purpose of understanding and insight)

The case study in this thesis is instrumental, embedded, and single case.

Theoretical model:

"*As with almost any other form of research, a good case study is built on the foundations of a theoretical model*." (Lazar, Fen & Hochheiser, 2010).

There are four aspects needed in the theoretical model:

- *Research question* (What does one wish to explore? What are the goals?)

- *Hypotheses* (The expectations from the case study, typically in the form of two contradictory sentences -H0 and H1)
- *Unit of analysis* (The focus, who is being studied? In which scenario are they being studied?)
- *Data analysis plan* (Which methods is used to gather data, and how is it analysed)

The data analysis plan is inspired by Baxter & Jack, which explain:

> *A hallmark of case study research is the use of multiple data sources, a strategy which also enhances data credibility (Patton, 1990; Yin, 2003). Potential data sources may include, but are not limited to: documentation, archival records, interviews, physical artifacts, direct observations, and participant-observation*. (Baxter & Jack, 2008)

Limitations

Limitations are first of all seen in the number of participants. This is most often a study of a phenomenon in a specific setting with a small size of participants all undergoing certain conditions, which excludes some chances of generalization. As the case study is a qualitative approach demanding an interpretative view, the limitations of the study can be seen in the interpretation of the data. An objective look can in addition be hard to maintain as the relationship between researcher and participants develops.

3.6 Experimental Research

Experimental research is a methodology that is based on experiments. The purpose of these can be helping: "*...to answer questions and identify casual relationships*." (Lazar, Fen & Hochheiser, 2010). The results from experiments are usually quantitative, as: "*The dependent variables are normally measured through quantitative measurements*." (Lazar, Fen & Hochheiser, 2010).
The hypothesis is often inspired by earlier work: "*The research hypothesis is generated based on results of earlier exploratory studies and provides critical information needed to design an experiment*." (Lazar, Fen & Hochheiser, 2010).
In this thesis, the experimental research is inspired by earlier exploratory studies, which is the case study.

Group design

The three ways to structure the experiments are according to Lazar et al. (Lazar, Fen & Hochheiser, 2010):

- *Between group* is an experiment that has two separate groups which never experience the same terms. (Need many participants, but less errors from fatigue and learning effects)
- *Within group* is a variant where one test two or more conditions on the same group. This is where the earlier considerations of learning effect is aimed. (Less participants but more errors from fatigue and learning effects)
- *The split plot* conducts research with between and within group design. (This takes on the positive and negative aspects from both).

The split plot design has been used in this thesis.

Limitations

"*One big challenge in HCI studies is that, in contrast to the* "*hard sciences" such as physics, chemistry, and biology, measurements of human behaviour and social interaction are normally subject to higher fluctuations and, therefore, are less replicable*" (Lazar, Fen & Hochheiser, 2010). The fluctuations mentioned can be seen as errors. There are two types of errors.

- *Random errors:* The more people included in the study, the less chance of errors corrupting the data. These error can be called "*noise*" (Lazar, Fen & Hochheiser, 2010) and refer to random events that alter the results.
- *Systematic errors:* Random errors fluctuate in every direction, but the systematic errors always tilt the same way. This bias can have many sources, and there are several ways of dealing with such.

3.7 Ethics

In social sciences there is often a wide range of subjects with their own limits to what they find acceptable. All the methods presented in this chapter are subjects to ethical issues, and so this topic will be mentioned here. Clifford has gathered some guidelines, inspired by several authors: *"1.Informed consent […] 2.deception […] 3. Privacy and confidentiality […] 4. Accuracy"* (Clifford, 2005). All four terms will not be explained, but Informed consent and privacy stands out

due to their roles in this thesis.

Informed consent:

The subjects within a study have the right to know everything about the research they are involved in. This includes the background, purpose and process. In the words of Clifford: *"First, subjects must agree voluntarily to participate—that is, without physical or psychological coercion. Second, their agreement must be based on full and open information."* (Clifford, 2005). The consent form and the information about the study were given to students who participated in this research.

Privacy and confidentiality:

This topic includes the privacy of those involved in the projects, and the confidentiality of the data. From Clifford it is explained: "*Confidentiality must be assured as the primary safeguard against unwanted exposure. All personal data ought to be secured or concealed and made public only behind a shield of anonymity.*" (Clifford, 2005). This topic relates primarily to the handling and presentation of the experimental research data from the thesis.

4 The case study

4.1 An introduction to the case and those involved

The case study describes the use of the iPad in the first grade students of junior high. Five iPads were shared amongst 27 students. The students started their semester about two months before the case study came in to effect. The study lasted from March 12th until June 22nd, 2012.

On the first meeting with the students, the researcher talked about the numerous ways that iPads could be used in school. It was agreed that they could use the iPads in ways they chose and install the applications they wanted, as long as they accepted by their teacher. They were free to search for applications that they liked and if they thought it could be beneficial for their learning, they were encouraged to mention the application to the teacher and the researcher. Statements such as – "*I'd love to see you guys find some cool apps to use*", were said as an attempt to inspire the students. The teacher made sure to point at the students he knew had already looked in to such and asked them to suggest some applications. The suggestions were met with praise from teacher and researcher, to show gratitude and acknowledgements for their efforts. There were however some barriers that had to be discussed. There was an understanding of the possibility to purchase applications. It was explained that if the students wanted an application that cost money, they would have to agree that this was something they wanted and then show the teacher and researcher, which would acquire such. During this experiment, they only wished for one application. This application was a very detailed mathematical rulebook, which included all current mathematics and quite a few upcoming forms of maths they were about to learn. The name of this application was "Matteappen" – which in English would be translated to "the mathematical application", just in a verbal slang form. At the end of this semester the app DragonBox, used later in the experiment that was conducted, was released and suggested by the students. This app was made by the high school teacher and his students locally which then became a hit instantly in the area[9]. However, as it was released close to semester end, we did not work much with it. The case study is only conducted within natural science classes and mathematics classes, due to the teacher of this class being a representative of those subjects. The students had access to Wi-FI the whole semester – though with certain days had their access revoked due to larger tests.

[9] http://www.dagbladet.no/2012/06/03/kultur/analog_digital/spill/app/ios/21843757/ (Last consulted 06.06.13)

Appendix # 3 shows a thank you letter written by the students after the case study was completed.

The normal classroom situation: From what is heard and seen prior to the case study and from conversations with the teacher, the typical classroom situation in this class matches those from any other class at school. What set the class apart from the rest, was the more modern and technologically interested teacher. Although most teaching was done through the traditional chalk and talk method, the teacher occasionally used projectors for class presentations and even allowed the students to use laptops, cell phones and iPads during class, just as long as they were used for educational purposes.

The new classroom situation: As previously mentioned, the class was given 5 iPads for the duration of the semester. This led to some unexpected decisions and the idea that students could bring their own iPads to the classrooms was suddenly of much bigger interest. The students had no real restrictions on them. The few restrictions that were, limited their use to the classes with this teacher, and the purchase of applications previously mentioned.
The teacher was given the password to the iPads, so he could authorize any and all applications they wanted to try and they were supposed to tell him about any application of interest. However, he quickly explained that he had given them the passwords, as he did not have time to look at every application they wanted to try – especially during their breaks.
Whenever they were observed, there was a particular effort made to give the impression they had been working on just this (at least that is what it felt like). Every time the observations were scheduled, the students in addition gave a quick 5 minute run-down of new applications they were interested in.

4.2 Argumentation for selecting a case study:

In this case, the interest was centred on a class of students that could be studied. An ethnographic study approach could have been attempted to blend in with the studied group. The need was primarily insight to a situation. Conducting a case study meant that the researcher aimed to study the group from the outside instead of being one of them, but they showed respect and treated the researcher as an authoritative personality. This meant that they gladly explained situations and answered questions at the end of – and sometimes during class. The case study covered the need of insights and provided the type of information sought.

Using an article written by Baxter and Jack (Baxter & Jack, 2008) the conditions of argumentation

for this being a case study would be:

- The purpose of this study, was to see *how* this supplementary technology would be accepted in the classroom ecology. Further, *how* it would affect the mind-set of those who used it.
- Manipulating the behaviour of those in the study, is out of the question.
- The context is of great importance. This should be done in a learning environment, as a part of the typical student day. The use of the iPads must be looked at from a learning perspective, not as fun and entertainment.

4.3 Theoretical framework:

The framework is inspired by the works on ecology by Forlizzi (Forlizzi, 2008) and Nardi and O'Day (Nardi & O'Day, 1999). Nardi and O'Day define ecology in the following way: "*We define an information ecology to be a system of people, practices, values and technologies in a particular local environment."* And further state that: *"In information ecologies, the spotlight is not on technology, but on human activities that are served by technology.*" (Nardi & O'Day, 1999). The ecology is the framework of all of these connections. A schematic diagram modified from Forlizzi (Forlizzi, 2008) is presented here to illustrate the imagined ecology which is investigated:

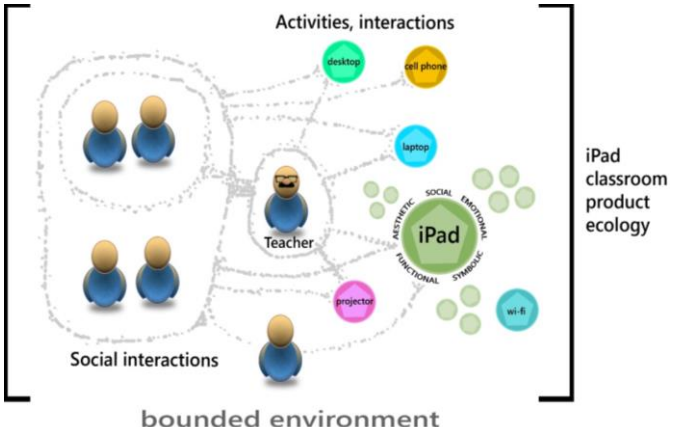


Figure 5. This figure illustrates the product ecology.

The ecology is presented with the people and their interactions in the centre, connected to the iPad as the main product of investigation. The interactions seen in Figure 3 are both individual and social interactions inside and outside of school, with all the activities and interactions connecting them to the products. In addition the teacher plays a key role in the relations between the factors. Devices the students bring with them and that are present in the classroom are presented as parts of the

ecology.

Type of case study:

For this case study the instrumental approach was chosen. The purpose of this study is to generate some insight in to a phenomenon that can be used to explain situations which one can find outside of the study. However in hindsight, it has taken a somewhat informal turn, as lack of experience and insight painted the planning stage, which was not quite what it should have been at the time. Further, this was meant for a single case study, with an embedded aspect.

Purpose and goal:

The research question aimed at the case study was as follows:

"Which role and what kind of effect will tablets have in a classroom environment of a junior high?"

People use the tablet technology to consume media. Typically TV shows, games and similar types of media. From the information found in the literature review, it is clear that this device is primarily focused on this aspect of consumption. We will investigate if the tablet is used in a similar manner in a learning environment and which role and effects the device will have.

Unit of analysis:

The participants of the study presented in class can be divided in two. There is the teacher with his goals and agendas, and there are the students with theirs. The main focus will be on the students, but the teacher, as the key element in this ecology, and his ways of handling situations and choices he made, were clearly of large importance.

The teacher: The teacher is a technology interested man, with several Apple products under his belt. He has Apple Laptop, iPhone and iPad. This gave the impression that he was more than aware of the capabilities of these. In addition, he is at the point of writing, pretty much the main person at the school when it comes to technology and "know hows". Whenever there are presentations due, he has to come up with the cables and solutions. Assumptions can be a dangerous thing, but even so – this man stood out as a perfect match for the project.

The students: The students in the class had no prior experience with projects, and they were very open minded and already quite interested in this type of technology. It is perhaps fair to mention, that many – if not most, of the students at this school, have parents with a heavy educational background – typically lawyers, doctors and such. It has a reputation to be a "rich" neighbourhood. The teachers and administration have many times mentioned this.
The class consists of a somewhat equal share of genders. The numbers are based on the notes from returned consent forms - with 11 boys and 16 girls.

Data analysis plan:

The data sources in this case study, will be focused on: Observations, Interviews and Documentation.

Observations:

Observations were conducted throughout the semester from the start of the case study (March 2012) to the end of the semester (June 2012). They were held in a bi-weekly fashion. The impression was given that the teacher felt some need to force the use of iPads when the observer was present.

During the observations, "*fly on the wall*" approach was used. The observations were conducted from the very back of the classroom. The role was very passive, and the observer attempted to remain quiet throughout the whole session. It proved difficult at times, as students sometimes had questions.

The framework for what was observed, was inspired by the classroom ecology presented in the case study chapter and uses the schematic diagram (Figure 3) as a foundation.

The observations would typically last for 45 minutes – which is a standard class for one topic. The topics observed were Natural Science and Maths. The teacher presented earlier taught both of these. Seven of these classes were observed throughout the semester.

The observations can be said to dabble between subjective and objective observations as it is the interaction between the subject and the object that are of interest. The observations took a structured form, where the interests were clearly lined out ahead of the observations through the product ecology. Further, the observations were conducted in a non-controlled manner.

Interviews:

It was decided that the interviews should cover as many students as possible within the given time-frame. A greater understanding was thought to be made if there were many responses and if the students could discuss the questions asked. One of the issues was the amount of time the students could dedicate to the interviews. This was at the end of the semester, and a lot of tests were headed their way. After an agreement with the teacher, we came to the mutual understanding, that one full class (45 minutes) could be dedicated from their time. The interviews were constructed in such a manner as to inspire the students to talk as much as they wanted around the topics, between themselves and to the interviewer. This was done in a hope to promote trust and conversation. The interviewer presented the questions in a semi-structured way, as the conversation progressed. This was inspired by Lazar et al. (Lazar, Fen & Hochheiser, 2010), which promote the aspects of reflection, insights and consideration. For example, when a student makes a claim about the use pattern during the interview, the answer is acknowledged, and they are further asked to explain it in greater detail, making him word himself differently to express his opinion. This is done in the hope that he will take the time to reflect on a claim that might or might not have been made in haste.
As a last note, all of these interviews were audio recorded. The data from the interviews will be looked at and interpreted with the use of content analysis

Interview process with students:

Three students raised their hands and went to the library, which was just across the corridor. We sat down around a round table. Some bags with candy were opened and they were given something to drink. Their mood was good and they were increasingly talkative. They were given the chance to ask questions about the process before the interview started, if there was something they would like to know – which some did. A set list of questions was slowly gone through, though trailing off at every possibility. Time for each group was at an estimated 11-13 minutes.
The interviews were held in an orderly type of conversation – which negated any type of conversation dominance, though bias could possibly have been there in the form of influence of opinions. An anticipated bias was that some students would agree with others due to some form of peer pressure. This was attempted avoided by asking a different student each question, and attempting to get detailed information about their attitude towards the different topics.

Interview with teacher:

The situation with the teacher was conducted differently. Due to his busy schedule it was found best to have an ongoing interview through emails. In this manner the interview took on an unstructured shape and was more in the form of a conversation. This allowed the researcher to ask questions about the teacher's answers.

Physical artefacts & Archival logs

This section is split in to three sources. All three are found on the tablets. The three are: the application history (including pictures and other media), the browser history, and the audio diary the students were requested to have.
The iPads had within them a large amount of information as they in theory had not been wiped since the case study started. This was supposed to include all application download history, all web browsing history, all pictures taken, and all memos made.
A voice diary was attempted, where the students were presented with a program during the first encounter, and asked to make a 10 second recording on what they had just used the iPads for after every use. This however was done once or twice on every iPad, and then never done again. After going through all the iPads, full access to the complete history of applications they had downloaded was achieved. Their full browsing history however, had been deleted by the students. This had been done on all the iPads.

4.4 The data collected during the case study:

The findings are organized and sorted after the type of data collection, first the observations and thereafter the interviews and artifact information such as logs. There are categories after each point, which is created to illustrate how the replies relates to a bigger picture.

Observations

In this segment the main findings from the observations will be presented. Some of them will be grouped up by an overlaying theme, while others will be directly quoted:

- The very first observation noted refers to the natural state in which the students are, when working with the iPads. The students have mastered the basics within days after acquiring

these devices. They quickly navigate through information and give off an impression of knowing exactly what to click. (Aspects noted of interest relate to ease of use).

- In contrast, other technology found in the classroom experience issues. The calculators for maths class are different depending on the manufacturer. The functions can offer different results (in "shortcut" areas) related to Sin, Cos and Tan functionality. The teacher and some students have used their mobile phone and iPad calculators to avoid this, but they are limited. (Aspects noted of interest relate to possible tablet effect on class).
- The school often has issues with their wireless internet. Some problems arise for the iPad because of this. Applications are still useable without Wi-Fi, but any use related to the browser or new applications is halted. (Aspects noted of interest relate to issues with device).
- Internet is shut down for days when important tests are held at the school. This is done so students cannot seek answers online, as many tests utilize laptops.
- Killing time is an aspect often seen in class. Minutes after the students were presented with iPads, some students had started applications or games unrelated to the class. It has been noted that the switching between applications is quick and contribute to a student's "sleight of hand" to avoid their time killing activities being detected. (Aspects noted of interest relate to issues with device).
- Cell phones are often utilized along with the iPads. The students would use them together, but sit with different content on each screen. From what is seen, one device (cell phone) is more often used to communicate with other students, while the iPads are left with the school related content up. (Aspects noted of interest relate to tablet effect on class / role of technology / issues with device).
- The teacher does not have full control over what the iPads are used for, by the students. Throughout the observation, the teacher was not observed catching one person in the act of killing time on the iPad. The view from the back of the class was more than sufficient in catching the students who did not actively try to avoid detection. Some screens were angled away in such a manner that they could not be observed without actively disturbing the students. (Aspects noted of interest relate to issues with device).
- The teacher was actively promoting the use of iPads in the classes. At the beginning of class, the teacher would ask which students wanted iPads. Throughout the observations, all iPads

were taken. The number of hands were in every situation seen higher than the number of iPads available. (Aspects noted of interest relate to student interest in device).

- The iPads were often observed leaving one desk (with the student) to show another student what they had found. When observed, the information present on the iPad was from a webpage where the student could point at the information he wanted to show the other student as he read. (Aspects noted of interest relate to social collaboration).
- Some of the classes featured group-work. The groups had one iPad each which was often used by one or two individuals in the group. The iPad would mingle between the group members slowly. (Aspects noted of interest relate to social collaboration).
- Attention was difficult to acquire when the students were immersed in the devices. Some students keep working on them despite the teacher's loud desire for their attention. It would often take a name mentioned by the teacher to get the attention and even then it did not hold for long, as their gaze went back to the tablet. (Aspects noted of interest relate to student interest / issues with device).
- After several observations the impression is left that students without iPads are more likely to engage in conversation. Students with and without iPad side-track often, but those with an iPad are from what is observed, quieter and focused. This means they are not involved in loud conversations unrelated to their class work. (Aspects noted of interest relate to tablet effect on class).
- While working on a project, 8 out of 10 groups had digital assistance. 6 of these were iPads and 2 were laptops. The students used the iPads to acquire information for their projects. None of the iPads were used to create a presentation. (Aspects noted of interest relate to role of device).
- The teacher acquired headphones for the iPads. The effect of this was hard to notice. However, when a student used his laptop which did not have such, it became very clear how much noise one machine could make. This noise was from learning material. (Aspects noted of interest relate to issues with device / role of device).
- It was attempted to keep a close eye on the tendencies of procrastination. There is no observed difference between the students that utilize digital equipment and those who not in this manner. This does not include the noise level the students make, only their activities. (Aspects noted of interest relate to tablet effect on class).

- When the students were left to themselves, many students browse between the applications to find something beneficial for the subject. Students were seen browsing several rule books and information related to the math topic. In the end, an application of interest was found and the student sat to study it for a long time. (Aspects noted of interest relate to tablet effect on class/ role of device).
- As the teacher leaves the classroom, the silence lasted for 10 seconds. Loud conversations dominated the room and any actual school work was on hold till further notice. (Aspects noted of interest relate to the classroom without teacher).
- As one student achieved a new record in a game he played, he felt the need to tell everyone around him about what he had done. It was interesting to see his reaction to the achievement. (Aspects noted of interest relate to gamification elements).
- Social interaction is the main cause of disturbance in the classroom. The conversation between students spread like wildfire. The students with iPads are observed less likely to partake in these conversations unless asked directly to participate. (Aspects noted of interest relate to tablet effect on class).
- For the last natural science class observed, the students presented their projects. The teacher had beforehand suggested use of iPads and applications for this and suggested 3d models of the universe or similar models to be used through the projector. Out of all the students, none used an iPad to present their work. The presentations were all presented by using power point, projector and laptop. One group used a YouTube video to show project-related information. (Aspects noted of interest relate to role of device).
- During the presentations, the students were asked to put the iPads down on the desk. This was seen as a way to deal with the lack of control over student activity on the iPads. (Aspects noted of interest relate to negating issues with device).
- The use observed has roughly been 45% reading (web browsing), 45% application use (includes reading in applications, such as rulebooks) and 10% YouTube (or similar) videos. (Aspects noted of interest relate to use of the device).

Interviews

This section will first present a short interview with the teacher of the studied class, followed by

group interviews with students. The interviews were held at the end of the case study. The interviews were held in Norwegian and have been translated.

Interview with the teacher

The interview with the teacher has been translated and the questions with the important responses are presented here:

- *When asked how iPad worked as a tool for education*, the teacher explains that there were a lot of good, free applications available for his students. The applications can be difficult for the students to understand and to find which have high quality in what they offer. This is where a teacher is allowed to shine he says, as he could help the students choose the applications that were high quality and focused on the right material for learning. He further explains that the few number of iPads were a problem, but that they managed to share them somewhat evenly, often through group work with large groups. Lastly, the teacher mentions that he wished to move the data many students questioned in class up on the screen through a projector, but that these were not installed at the time of the case study. (Aspects noted of interest relate to role of teacher / social collaboration / role of technology).
- *When asked about his experience with iPad and what he finds beneficial for the classes*, the teacher explains that he finds the mobility, availability, and the ease of access superior to all other devices. This is because he can pick up the iPad and have everything available instantly. No turning the device on, no codes and no hassle. (Aspects noted of interest relate to role of technology / motivation / effect).
- *When asked about his experience with iPad and what he finds negative*, he explains that it was difficult to see if the students were paying attention and following his instructions. He explains that they could have a rich "inner" life on the iPad, because he could not see what they did. From his experience, the students had to be monitored. He further explains that this is something he has to do in every class. (Aspects noted of interest relate to issues with the device).
- *When asked if he noticed any difference on the class when they used iPads*, the teacher explains that the classroom was very quiet compared to when they did not have iPads. Even when they worked with one device per group. (Aspects noted of interest relate to tablet effect on class).

- *When asked how the students spoke of the iPads*, the teacher felt as though the students imagined themselves a lot better with this technology than him (he refers to old age and how that is often associated with being technologically outdated), but he explained that he had many chances to show how much he knows and that they are constantly surprised. (Aspects noted of interest relate to role of teacher / possible issues with adaption).
- *When asked if it is difficult to plan the classes for iPad use*, the teacher explains that it is not necessarily hard, but that the teachers have to master the aspects of the device. Controlled or guided teaching is an important part of the iPads according to him, as you cannot send your students blindly out in cyberspace. (Aspects noted of interest relate to role of teacher / possible issues with adaption).
- *When asked if some students were better with iPads than others*, the teacher explains that those who thought they knew everything were a bit surprised, but the girls who approached it more carefully had an easier time with the tools. (Aspects noted of interest relate to ease of use).
- *When asked if the teacher was required to take any special consideration with the use of the iPads*, he explains the students were very careful and respectful of the equipment, though some chargers disappeared. They were marked with who owned them and which iPad they were for, but that did not help. It went surprisingly well, he explains. (Aspects noted of interest relate to student respect for device).
- *When asked if he saw any different between regular and iPad enhanced group-work*, he explains that he found the iPads to have a positive effect on the group-work, especially with noise levels. He would have liked to try sending the iPads home with the students to finish the tasks they were given. (Aspects noted of interest relate to effect of tablet on class / social collaboration).
- *When asked which aspects of the iPad they used for learning*, he says that they attempted lessons and tutorials from YouTube and that equipment was bought so the students could listen to a lecture together on one iPad. This however went badly due to the bandwidth available at the school. In addition, the teacher explains that many applications were used. (Aspects noted of interest relate to role of device / Disruptive technology / social collaboration)
- *When asked if he thought the iPads added something extra to the classes*, he says; Yes, definitely.

- *When asked if he wants iPads for his whole class*, he responds; without a doubt – yes!

Interviews with students:

This interview is presented by the main questions which were behind the conversations, as there were many detours due to the semi-structure take on the interview. The essence of the answers have been placed under the questions from which they originated, because the original interviews were close to 15 pages of information. A content analysis of the interview is presented in the next section.

- *When asked if the students had iPads at home*, many explained that they do. Some students have several in the household. The students who speak about using iPads at home only mention use related to fun (movies, media, sports), except for one student who brought up DragonBox. The students who mention type of use, list games and entertainment often. The places mentioned where the iPads are used, are in the couch or in bed. (Aspects noted of interest relate to role of device / situation of use).
- *When asked if the students brought their iPad to school,* a student says that many students bring iPads from home. Some students say they bring iPads from home, but borrowing one from school is the best. More students bring laptops to class than iPads, according to the interviews. Students report less constricted use when bringing iPads from home, but further explain that the use is often unrelated to school. They explain that if they do this, it is like having your mobile in your hand. (Aspects noted of interest relate to use of iPad / Difference between private and school owned devices)
- *When asked which other type of products they use during class*, laptops and cell phones are often mentioned. All students asked have other machines than the iPad. The answers show that having a laptop at school means the students do not use iPads. Laptops are seen by the students as more advanced than the iPads and they can run more software. A discussion erupted from a topic about software, as some students were not aware that you could own Word and similar software on an iPad. The students also agree this is easier on a PC (or laptop). Some students explain that when they use their own iPads it is not used for education. Using a projector is mentioned rarely, but the few mentions show that they are used often. (Aspects noted of interest relate to role of device).
- *When asked what the students use the iPads for*, the students explain that using an iPad in classes has made the classes more fun. Some explain that they have been helpful towards

projects. (Insinuating that this is all they have been used for). Applications and browsing are mentioned as the most used functions on the iPad related to education. DragonBox is mentioned by a student and it is explained that they think they have learned some aspects of maths better. The student also reports that the tests feel easier after the use. Math and natural science are mentioned here and the typical use for the latter is 3d models of atoms, organs and more. The students mention these with enthusiasm. The use "Text" is mentioned for mathematics, by which he means rulebooks. They report having no problems finding applications for either subject. iPads have been used for projects by students who did not bring laptops, but the only reported use was browsing. Students reported that their teacher had some courses which helped them improve with word editing software and PowerPoint. Some students mention note taking and that one student has an iPad with a keyboard. From this they explain that she uses it as a PC and show signs of envy. Another student explains that he brings his iPad to take notes. When he returns home this is transferred to his computer or notebooks. Lastly, listening to teachers is reported as very boring (Aspects noted of interest relate to role of technology / Motivation / chalk and talk method).

- *When asked about the number of iPads they had and if this was a problem*, the students explain that sometimes they argue over who can have the iPads. It is reported that 10 students run towards the locker every time they are allowed iPad use. They further report that everyone thinks the iPads are fun and they want to use them.. Students explain that the teacher sometimes have to decide who can use the iPads, due to the demand. One student explains that he has barely used an iPad because there are too many students interested. He says he is content with being able to use his cell phone for the same purpose. (Aspects noted of interest relate to cool factor / Motivation / effect on class).
- *When asked how much they had used the iPads*, they report to use the iPads "some". However, from the discussion it became clear that it was often. The students explain that the iPads are mostly used for maths and natural science, but have been used for other subjects too. Norwegian class is mentioned, where the purpose was to measure reading. The iPads are reported often used during recess. They have been allowed to borrow these if they want to use them. (Aspects noted of interest relate to role of technology).
- *When asked if the students prefer reading on iPads or books*, iPads are preferred to read on by all students asked. Zoom capabilities and size are mentioned as reasons. According to a student, anything digital is more fun. One student explains that this is something they much rather want, as buying and bringing many notebooks to class is a hassle. When discussing

books, the students explain they have errors in them and are outdated. School economy is brought up as an explanation. (Aspects noted of interest relate to role of technology / motivation).

Data from artifacts:

The apps found on the artifacts are presented in Table 1. Some names are shortened, as this was how the logs presented them. It was not possible to click on the names or get a better description. Apps refer to application name, “edu” and “fun” refers to the purpose of the applications which is either educational or fun. Lastly there are the names of the five iPads, which show where the applications were found.

APPS	edu	fun	iPad1	iPad2	iPad3	iPad4	iPad5
0 planet	1				x		
0 solar	1				x		
3dFemale	1				x		
3dMale	1		x		x	x	
alien jump hd		1	x				
Bakery Story		1	x				
brain teasers		1		x			x
BTD4 Lite		1					x
Burrito		1	x				
Cake Pops		1	x				
calc shoot lite	1					x	
candy		1			x		
chemie	1				x		
ChemIQ	1			x			
Chocol...Teste		1	x				
classic books		1		x			
collection		1					x
Coloring		1					x
ColoringKids		1	x				
comics		1					x
convert units	1			x		x	
converter	1			x		x	
Cookie maker		1			x		
Cupcakes		1	x				
D-cardiology	1			x			
DidYouKnow		1		x			
Documents	1			x			
dr evil hd free	1				x		
dragonvale		1				x	
Draw Free		1	x	x	x		x
dropbox	1		x	x	x	x	x
emoji free		1				x	
F.Maker.HD		1			x		
f18 car...lite		1	x				
facebook		1				x	x
Fairy Colors		1	x				
frame magic		1	x				
Frosting		1	x				
Glow Draw		1	x				
Heart	1		x	x	x		x
history books	1				x		
HowToDraw		1					x
iAnnotate	1		x	x	x	x	x
iElements	1			x			
iMathematics	1			x			
instagram		1		x	x	x	x
Itunes U	1						x
jetpack		1			x		
Khan Academy	1						x
kinetic balls	1				x		
KingofMaths	1		x		x	x	x
KitchenSubs		1	x				
legebo...prøve		1					x
lorax hd		1				x	
Math	1			x	x		
	Total	Total	sum				
	23	32	55				

APPS	edu	fun	iPad1	iPad2	iPad3	iPad4	iPad5
MATH	1				x		
math drills lite	1		x	x			x
Math kid	1						x
matteappen	1		x	x	x	x	x
Milkshake		1			x		
molecules	1		x	x	x		
mr melk		1	x				
MrChocolate		1	x				
mulberry		1			x		
my pet rex	1				x		
newton's cradle	1				x		
order up!!		1	x	x	x	x	x
PaintSparkles		1	x				
papidrive		1	x				
paradise hotel		1				x	
parking free		1	x	x	x	x	x
periodictable	1		x				
Pizza		1	x				
PS 2012		1		x			
psychology		1			x		
psychology book		1			x		
quickvoice	1		x	x	x	x	x
regnemester	1		x				
rumble		1	x	x	x		
Sandwich		1	x				
science 360	1				x		
science@VL	1				x		
sciense books	1				x		
skateboard		1	x			x	
sketchbookX		1	x				
sodoku2		1				x	
spotify		1				x	
Sundae		1	x				
tap the frog		1					x
tmt sect. 1		1	x	x			x
tower defense		1					x
tv2 sporten		1	x	x	x		
unit...ersion	1					x	
sodoku2		1				x	
spotify		1				x	
Sundae		1	x				
tap the frog		1					x
tmt sect. 1		1	x	x			x
tower defense		1					x
tv2 sporten		1	x	x	x		
unit conversion	1					x	
units	1			x		x	
Vaskehjelpen		1		x			
vg pent.no		1					x
viddy		1					x
virtual heart	1		x			x	
vision test		1					x
WeddingCake		1	x				x
wordfeud		1	x				
Wordshortcuts		1		x			
	Total	Total	sum				
	17	38	55				

Table 1. Complete list of logs from the iPads.

The rest of the information found in the artifacts is presented in Table 2. The pictures which were found on the device were all related to “fun” and are not presented in the thesis. The voice recordings were investigated, but no relevant data was found other than students having fun with the microphone.

Kiosk	**edu**	**fun**	iPad1	iPad2	iPad3	iPad4	iPad5
Science news prime	**x**				**x**		
vogue		**x**			**x**		
Browsing history	**edu**	**fun**	iPad1	iPad2	iPad3	iPad4	iPad5
nothing			**x**	**x**	**x**		**x**
daria.no	**x**					**x**	
sys-temkretsløpet	**x**					**x**	

Table 2. Additional logs found are browsing history and kiosk purchases.

4.5 Summary and analysis:

For student interviews, the content was analysed according to what they said about meaningful categories which were defined from the interviews and the related literature. The interview with the teacher was simply summarised, as were the observations from the study.

Observations summary:

A summary of the observation show that students are interested in iPads and find them cool.
The students were proficient with the software quickly and managed to grasp the basics within days. The product ecology was rich and features cell phones, laptops and tablets. The use of these varied greatly, as students would either sit on one device during the whole class, or two. All three were not seen used together by the same students. It was never just one product used in the classes. The students use tablets much like they use cell phones. The difference is that when borrowing an iPad from school, the use observed was mostly directed towards the class. Cell phones were used for educational purposes as well, but there was more private content accessed on these. This private content can be troublesome for the teacher, as he has no real way to monitor the devices.
The students who do not use an iPad are louder than the students who do. They make more noise, but according to the observations they are not more likely to deviate from work than the students on iPads. This means that with and without use often deviate from class related work, but that the students without iPads cause a bigger issue due to the noise they make. Lastly, social collaboration has been observed frequently in class. The iPads often make their way through the classroom and are used by groups to find material for presentation. The students who share iPads are not as quiet and immersed as the students who has one each.

Interview with teacher summary:

A summary of the teacher interview show that the teachers role when the classroom scenario changes to iPad driven education, is to facilitate the software which is used. The students do not always know what to look for, nor what makes an application good quality. This is where the teacher and his judgement makes a big difference. The teacher's role is also to make sure the students are focused on classwork, but monitoring these students was challenging.
The number of iPads in the class was an issue for everyone. It was not enough to make the groups small and compact (2-3 students), which meant that when the classes were focused on iPad use, it

would have to support bigger projects. This caused a problem, as the classes which supported iPad required all students to be digitally enhanced by a device connected to the internet.
The best aspects of the iPad are seen in the mobility, availability and ease of access the device offers. It was clear that amongst devices lent out by the school, this device was a lot less hassle to the teacher and the classes than the laptops were. Another positive effect noticed by the use of iPads was the noise levels. Students who used tablets were less noisy, even when in groups.
The last aspect summarized is the new form of teaching that arose when this technology was used. The classes tried to learn parts of their curriculum through the use of online sources such as YouTube and online lectures. This approach was however aborted due to bandwidth issues.

Content analysis of interviews with students:

Creating the categories and a coding scheme for the content analysis:

When creating the coding scheme, parts of the interview was investigated. These terms have foundations in related literature to the field.

Platform: This category was chosen because of the interesting comments regarding technology. The case study itself was centred on the iPad, but responses indicated a rich ecology of products.

Situation: This category is focused on the location which the iPads are used. It also includes some comments regarding the classroom situation. This is to get a greater insight in to where the primary use of the tablets lies.

Motivation: This category is focused around the student impressions and reasoning for choices related to tablets. This includes what they feel is positive, negative, inspiring, encouraging and fun. The purpose is to get feedback on their enjoyment of the device.

Technology vs: Some responses directly compared products against each other. The role of the technology could be seen in relations to the already implemented technology and how this was used. The interest is to see what separates the products from each other.

Use: This category focus on how the students actually use the tablets and other devices. This category was often split in to Consumption and Production segments, as these categories are of special interest.

Problems Some issues arose in the classroom. This includes technical issues with the devices, but also other issues that affected the overall experience.

These categories are all tightly connected with each other as is illustrated by the product ecology. The connections are displayed in Figure 6: which shows that everything is connected.

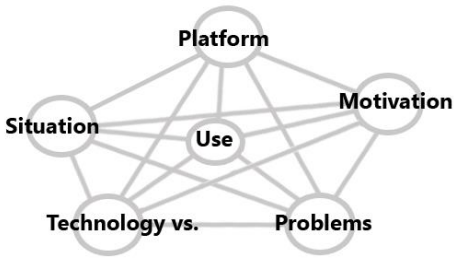


Figure 6. This figure illustrates the connections between the created categories.

Results:

Category	Findings
Platform	- The platforms mentioned were: iPads, iPods, Cell phones, projectors, Laptops, Macs and PCs. The most frequent of these were iPads. Figure 7 illustrates the differences. - The students were very clear on brands when it came to iPads and iPods and Macs. Most used the terms Laptop or PC, but some were also inclined to specify the brand, though only owners of Macs. - When asked, the students also explained that they all had additional stationary hardware in the form of PC or Mac
Situation	- Many students had tablets at home. Only iPad was mentioned through the interviews. In most cases where iPads were used some students have brought iPads from home, and use them in the designated classes. - Home and at school are the main places mentioned for use. - Situations arise due to the popularity of the device. - Six students were asked directly if they owned a tablet at home, where five stated that they did.
Motivation	- From replies related to the student impression of the tablet, not one was negative. There replies were typically: “like to use”, “pretty good”, “fun”, “a lot more fun”, “a lot easier”, “very user-friendly”, “very fun”, “really fun”.

	- Comparison between the tablet and books show that in every case the students prefer the tablet (digital) version. Reasons mentioned are; the size of the device, weight, and easier to use than a book. One student was motivated because he did not have to sit with a monster book, which "psyched" him out, from reading the books (explained more closely that it was demotivating to see the large book). Also, the books had very outdated content, which is an issue not found on the iPads. - One student reports feeling better at a subject after having played through an educational game-application called DragonBox. - De-motivation is seen when a student discuss the classes. He explains; "it becomes so boring to listen to teachers". Two other examples of lust for variance is also found elsewhere in the interviews.
Technology vs	- The iPad has in many cases during the interviews been described as easy to use. The finger guided menu has also been positively mentioned by the students. - One of the biggest drawbacks mentioned for the iPad was the lack of flash. (Flash is a media content player of sorts that is used for many streaming sites to relay content to the user.) - The iPad is compared to and found better than windows systems which is seen as difficult and not optimal (closest translation). The students who mentioned such also explain that apple products were; "easy", "easy to use", "fast", and "quite similar". - The iPads were seen as "cosy", while the stationary machines (including laptops) were seen as easier to work on. - The teacher offered students a course for Mac (their word, as the software is not Mac specific). This was about Word and PowerPoint software. The goal was to show how to manage and design the documents for them to look clean and simple. This was done on a projector. - It was mentioned that when there was a lack of iPads available for the students, they would find the applications they wanted on their cell phones.

Use	- The consumption aspects of the different use patterns from the students go far and wide. Most students explain that they use the iPad device to gather information. Terms used were; “gather information”, “find information”, “google and wiki”. The description “read” is used frequent. There were no books found on these devices, but two magazines. - Games are mentioned by most – and applications for subjects are mentioned by many students. Other mentions are social networks, primarily YouTube and Facebook. The differences between fun and educational use can be seen in Figure 8. - Several applications are mentioned where students can view (and manipulate) objects for natural science. In mathematics the tablets have mostly been used with rulebooks. Lastly there has been some use in Norwegian classes, where they have measured reading speed with the tablets. - Twenty seven (27) mentions were directly related to the consumer aspect, Six (6) were related to the Producer aspect (See Figure 9). From this, five were related to writing notes and reports in class. The last example was taking screenshots. - There were some discussions about programs for the tablets, such as key note (that would allow presentations and documents to be more easily created). Further they explained that the student that possessed a keyboard for her tablet was incredibly lucky, and they all wanted that.
Problems	- Noise is a description that came up often. The class in general was noisy, but some extra was added when the students argued on who would have the iPads and noise from when they were used to watch movies. - Software available on the iPad was seen as limited, because the more advanced software was not available on a tablet. - The teacher experienced difficulties dividing the tablets between the students. This led to a frequent use of “first one there, gets it”. - Monitoring use of the devices is difficult.

Diagrams from the analysis:

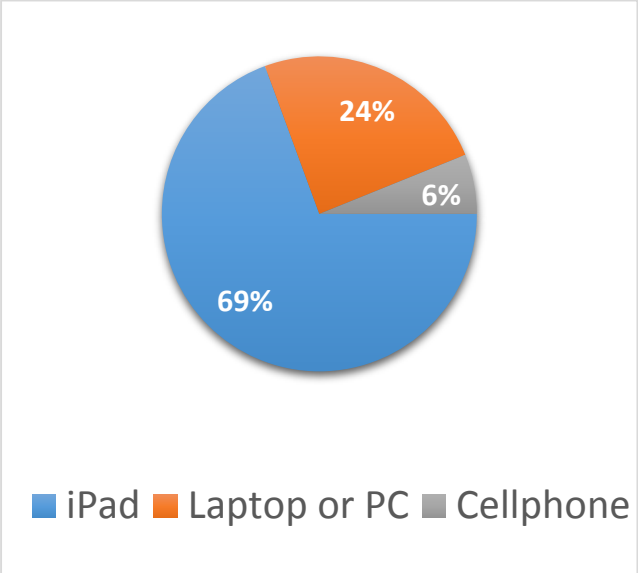


Figure 7. This figure show a graph over most mentioned technology..

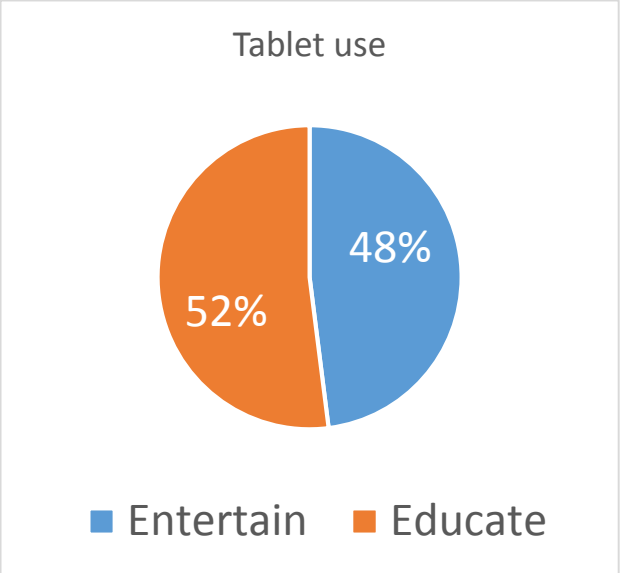


Figure 9. This figure shows which aspects of the iPad students discussed.

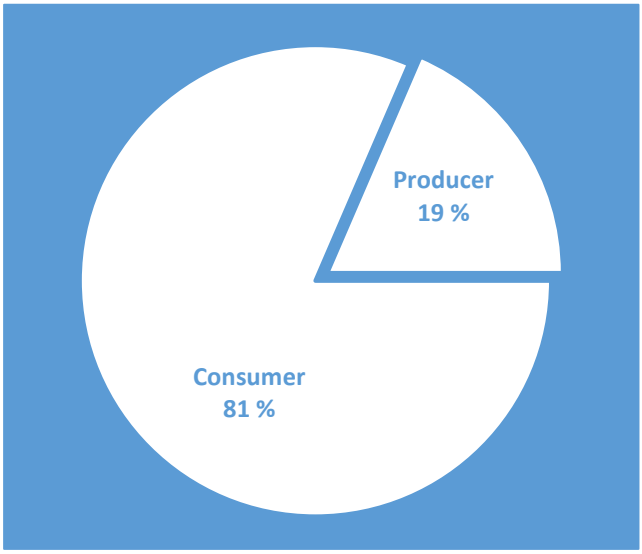


Figure 8. This figure show consumer vs. producer trends.

The diagrams chosen are created to illustrate topics presented in the content analysis of the interview. The diagrams show how often different topics were mentioned. In Figure 7, we see the iPad is discussed vastly more than any other technology. In Figure 9, we see that consumer trends are mentioned noticeably more frequent than production trends. In Figure 8 we see that educational purposes were mentioned as often as entertainment purposes in the interviews.

Coding consistency:

Having developed a coding scheme (Table 1), segments of the interviews has been compared with this scheme with another coder. There were 32 examples from the text compared, which can be seen when adding up all the cases (bottom right in Table 1).

	Platform	Situation	Motivation	Technology vs	Use	Problems	Row total
Platform	9 (3,09)	0 (1,13)	0 (1,69)	0 (0,56)	0 (2,25)	0 (0,28)	9
Situation	0 (1,03)	3 (0,38)	0 (0,56)	0 (0,19)	0 (0,75)	0 (0,09)	3
Motivation	0 (2,41)	0 (0,88)	6 (1,31)	0 (0,44)	1 (1,75)	0 (0,22)	7
Technology vs	0 (1,38)	0 (0,50)	0 (0,75)	2 (0,25)	2 (1,00)	0 (0,13)	4
Use	2 (2,75)	1 (1,00)	0 (1,50)	0 (0,50)	5 (2,00)	0 (0,25)	8
Problems	0 (0,34)	0 (0,13)	0 (0,19)	0 (0,06)	0 (0,25)	1 (0,03)	1
Column total	11	4	6	2	8	1	**32**

SUM Agreements=	26
SUM of frequency=	7,06
Evaluation Kappa=	0,76

Table 3. This table shows the calculated agreement matrix between the coders.

What we see from the data is that the Kappa evaluation is larger than 0,7. This means the inter-rater reliability *is satisfactory.*

A closer look at the Artifacts and archival logs:

Audio diary was attempted, but the students did not take a liking to this form of logs. This led to them not being used, and as the devices were investigated, only three such logs were found.

All in all, there were 110 applications installed, throughout the semester. These have been split in two categories the first is “educational” – here representing if the application has a clear educational purpose, such as exploring molecules and the likes. The other is “fun”, which can be anything from a beauty magazine application to fart-master 3000. Further listed on which of the iPads these applications had been installed on, and compared to general popularity of the applications. Out of the 110 applications installed, 40 were of a varying degree of educational purposes. Some of these might be the mathematical rulebook, or simply be games with educational segments. 70 of the applications were listed under the fun category. In most situations, the applications found were only installed on one device. It is however of interest to see which were spread on more than one, and for which purpose.

Number of devices	Descriptions and statistical information
Two 2 Brain teasers Convert units Converter Facebook Math Skateboard Units Virtual heart WeddingCake	Closer investigation show that there are nine applications. Four of these are listed under the fun category, though some had been deleted from the app store since this project was finished. This means that five of the applications are related to education. Converting numbers could be a handy tool for mathematics and natural science. There are three applications that share this purpose: “convert units, converter and units”. Virtual heart is a 3d model version of the human heart application.
Three 3 3dMale Math drills lite Molecules Rumble TMT sect. 1 TV2 Sporten	For the applications that were found on three of the iPads, half were educational and half were for fun. The grand total of six applications show a tendency of steady decline for educational purposes. In this section, the applications were focused on mathematical equations and more 3D modelling. “Math drills lite” is an application that offers equations to solve. It is very straight forward and offers only numbers like “9x5=”. It has no gaming elements from what is presented in the app store, nor on the website.
Four 4 Draw Free Heart Instagram KingofMaths	Following a steady decline in application spread, we have a look at the applications that four of the iPads had installed. In this case, two of the four applications were fun and games, though – king of maths does have very clear gamification elements. It is very clearly an education type of game. This is the first encounter with students playing games to learn a subject.
Five 5 Dropbox Matteappen iAnnotate Order up!! Parking free Quickvoice	In this category most applications have been installed by the researcher. Out of the six applications here, four of these are pre-installed. Meaning only two applications made their way to all the iPads without the interference of the researcher. The math game called “Matteappen” was an application that the students came and asked for. The two other applications were “Order up!!” and “Parking free”. Both being free game applications.

What can be extracted from this information, is that the spread of applications over the iPads was somewhat sporadic. It is hard to tell whether the spread is from word of mouth as recommendations, or just installed by someone eager – borrowing a different iPad every time. The teacher was talking about these applications before the case study and the students have listened.

It is also very interesting that the one educational game they found, had made its way to four out of the five iPads. This would back up their claims of interests in such games.

Further information can also be found in the browsing history. There was a grand total of two pages in it, so it is very clear that the students themselves have wiped any browsing history. The first page went to something that explains how the body works, directly translated it would mean the circulatory system. The other page however, was to something called Daria.no. This is a page students use to cheat their way through papers. It has been known to some teachers for a long time. A teacher explained that students find and post papers on all topics on this site, and that it is often directly printed out and handed in. The use of such pages could potentially be the reasoning behind the removal of browser history, but there is little evidence to support this.

4.6 Ethics

It was attempted to avoid explaining exactly what was measured in this case study, which were consumer and producer trends (degree of deception). The goal was to grant the students the possibility to use a device, but in no way guide them to how. It was explained to them that how they used the device was of interest. The students were to be able to download games if they wanted, and not feel as if everything was watched and analysed.

Consent forms were signed, and they were notified of different types of recordings that was interesting in, as well as pictures. They were able to select if picture could be taken during the classes, and as some said no, it was best to avoid it all together (the pictures).

The consent form can be found in Appendix # 1

4.7 Discussion of overall findings:

The role of the device in an educational setting is the focus of this study. Does the role of the technology fit well with what we see in households or does it have another role? How have the students used the tablets and what have they used them for? What are the effects from the use of these tablets in classes? These questions are based on the research question and will be discussed here based on the findings from the case study.

When can they use the iPads: The students have had access to the device for nearly a whole semester, but what the students explain in the interview is that these are locked up until situations where they can be used. In contrast some students have explained that they have been allowed

access to these between classes. Not surprisingly, their education is primarily focused on the chalk and talk procedure. When they have reached places where this technology can be used to strengthen the learning, they have been granted access.

What type of educational content have they been used for: From the students we have gathered that their most frequent use is gathering information. From all the feedback during the interviews and observation, the use is slightly more varied and includes note taking, social networks (sometimes educational perhaps, as their class has a group), educational applications and some educational gaming.

Role of the technology: From all of the methods investigating use of this device, no evidence has been gathered that it has been used in any other ways fundamentally different from a normal laptop or computer. If we look at aspects such as group work, it was more encouraging due to the way the students were seen using these devices and their feedback. The device functions like a normal laptop in regards to the role, due to every description of use and any observed use. It can be hard to define just where the borders of supplementary technology is located, but most of the use is clearly supplementary. Several reasons can be promoted for why this device can be seen as a supportive technology to the education, but there is evidence that would contradict this. The first piece is the applications used to give the students a hands-on experience through manipulative 3d objects. This way the tablets were used to teach the students in a completely different way. The other example is from when the class tried to watch classes and tutorials online instead of having the teacher explain. In this scenario they attempted to use the tablets as device to facilitate teaching (still most likely done through the chalk and talk method), rather than supplement the normal class procedure. This is disruptive because it changes the role of the teacher in the classroom and because it could to some degree alter what we today associate with the classroom. They could easily do this from home in their beds. This did however not work. The use was aimed at supporting the curriculum and the devices seem to be limited to helping the students find the information on this, in one way or another. The hands on approach through the 3d application does bring the curriculum to life in a new way and is seen as a way to play with and research an object on their own terms. Most of the time however, the device is basically either a new, better, bigger course book. The book is however available for all classes and yield tools for most. Such as mathematical rulebooks – or a new notebook to write notes in. It does not add much new, it only finds new smarter ways to promote the same material. The fact that this device can cover all of these roles might one day make it fundamental in classes just because it has the opportunity to merge the borders between subjects and the way material is presented. This device clearly has the capability of being more than a

supplementary tool, but despite this we see a clear trend of careful use and a supplementary roles. The competition between the devices in the ecology might have some blame for this, as we can see trouble with this aspect through examples such as: Many students were aware that the iPads could have software that allowed them to have presentations through these devices, yet none of the students decided to do this – despite the teacher advocating for the possibility. The device could clearly be used for this purpose, but the students selected other means.

Consumer aspects: The consumer and producer aspect can also be looked at in greater detail. The use that was not related to education was a frequent phenomenon in classes. Gaming was high on the list when it comes to use. It was mentioned frequently in the interviews and the list of installed applications clearly show games as something the students really enjoyed. None of this use was promoted during the classes by the teacher, so the students either had to do this during their breaks, or behind the teachers back. The sheer number of games installed increase the chances that this is something they have done during class. The observations conducted do also support this notion, as several of the students were observed playing games and quickly switching away after they noticed they were seen. An explanation can be that some students finished their work and decided to play games instead, but this is likely not always the case. The aspect of entertainment can be seen everywhere. Interviews show that students found this device something they would be very likely to use while in the couch or in bed to watch programs like sport or play games. From the installed applications, we see that sports has been watched through TV2 sporten (translates to sports, but the original name is kept as it is a program on a TV station) application. From this information it became clear that the use is similar to what one could expect from home use. There are some slight differences, but overall there is nothing in the use that stands out other than the fact that they were interested in studying with the iPad.

Producer aspects: No observed production of any sort has been seen during the observations, nor do the logs in any way confirm additional software downloaded that would allow this. Dropbox and iAnnotate have been pre-installed, but they were unmentioned in the interviews. The issues could perhaps be because of the difficulties in saving the notes. If you were to bring your own tablet, it would be easy saving these as they were on your iPad. Laptops however are different and as you have to log in to your own user, you will always have access to your documents no matter which PC you are on. The purpose of Dropbox was to correct this, but it looked unused. The students however claimed that the tablets had been used to take notes. An explanation can perhaps come from the observations, as all the students had created digital presentations on computers. This insinuates that perhaps the tablet device is not inviting enough or lacking when it comes to creating content.

Effects on learning environment: So far we see the effects of the tablet has improved student learning by granting new and updated information, encouraged hands on learning with 3d objects, and according to the teacher – reduced noise levels. However, from observations we can see that many students still avoid focus on learning, by playing games or other related activities during class. In addition, several students explain that the variation in learning due to these devices have been very desirable. From all of the responses by the students, not a single negative description was had when discussion the tablets as an asset. The use of technology has seen a large increase after the introduction of these tablets in the classroom. The mobility and availability was helpful when assessing if the students are allowed to use them or not. Overall it looks as if the devices have been used with great pleasure and interest amongst the students. The technology has brought something special to the classes in the shape of applications, but perhaps at the price of too much freedom. School computers can be very limited in the access you have to installing software, so this can be a somewhat unique ability, though shared often with that of the cell phone technology (as the students claim to have applications on either). It is hard to avoid seeing the tablet technology as something between cell phones and laptops, though lacking some from both aspects, but keeping the best of both. It is very clear that tablet technology is going to replace laptops when the creators of such have managed to make the tablet more production friendly, as this point is the only area where the students would rather use other types of technology.

5 Experimental Research

5.1 An introduction to the experiment and those involved

This study was conducted during the fall semester of 2012. 5 iPads where given to a class consisting of 27 students. The time-frame for this study was between October 8th and November 9th. It was scheduled for three weeks, but after a discussion with the teacher, and the amount of tests the students had ahead of them at the time, we decided to push the schedule back slightly. This was to make sure everyone interested had a chance to try DragonBox.

It had been about four months since the case study. This was the same class that had partaken in the first case study and they were chosen to be the participants of the experiments. These students had found the game and wanted to try this application. Admittedly this could create some bias as to the motivation, but since everything was optional it was easy for the students to avoid the application entirely. Due to the previous experience they had, consent forms were handled easier.

DragonBox is the focus of the experiment. No information about the application itself was given to the students. They only knew what they had heard or read from others. During this one month long study, the students and the teacher would be free to use the iPad however they wanted, but the teacher was given the control over the devices. No directions or instructions were given. The purpose of this was to see how the students and teacher would understand the application, and use it as in a way that felt natural.

At the time when the last tests were taken, someone working for "WeWantToKnow" (which created DragonBox) came in contact with the researcher. They were interested in partaking in the study, but they gave the impression of carrying some metaphorical luggage that the researcher felt could bias the research. Therefor the impact they made was not noticeable, but the data was made available to them. They did however explain that there were some information available at their web pages that could help facilitate learning with their application. However this was too late to impact the study.

5.2 Argumentation for selecting experimental research:

The goal of this study was to see if students would improve in attitude and performance. The performance is something that can be measured with statistical tools. The quantitative data approach needed for this, and the focus on the tests advocated a use for experiments. It was no longer a question of merely observing students, but rather measure them. Experimental research is a

methodology that is focused on experiments, and therefore it was chosen.
In addition to this, the attitude of the students was investigated. This aspect cannot be measured through numbers, and seen through statistical tools. That means this study does to some degree take on aspects from ethnographic, or instrumental case study approaches in seeking to understand a phenomenon. Methods such as observations and interviews are more closely connected to this.

5.3 Theoretical framework:

The theoretical framework is highly influenced by the case study approach. This is because the ethnographic methods of investigation used in the case study, such as observations and interviews have been chosen. The product ecology presented in the case study has been used in some methodologies associated with the experimental research. The methods of investigation used are very similar to the case study, as the qualitative data was wanted to support and enrich the quantitative data gathered from the tests.

Purpose and goal:

The purpose and the goal can be seen in the second research question presented at the start of this thesis: *"Will learning math with help of apps like DragonBox motivate learning for junior high students and improve the learning outcomes?"*

This time the focus was split between the process, motivation, and results. The interest behind the process, was seeing how the teacher and students would utilize this opportunity, and how the classroom would work when this new tool was introduced for math education. The motivation was directed at several aspects, such as social collaboration, attitude, and enjoyment. The game would have to motivate the students for them to play it more than once. The students would have to like the game and find it rewarding and challenging. The results will show how rewarding such an application can be to a student.

Hypothesis:

The hypotheses for this experiment is stated as following:

H0=*Frequent use of DragonBox on tablet will improve results and motivation in math classes for junior high students.*

H1=*Frequent use of DragonBox on tablet will not improve results and motivation in math classes for junior high students.*

Experimental Design:

The experiment can be described by its variables and conditions. There are two independent variables, and one dependent variable:

Independent variable 1 = Time spent playing DragonBox (high or low frequency)

Independent variable 2 = "pre-use" and "post-use" tests

Dependent variable = results outcome

The groups of students are split from the total amount of hours they have played DragonBox. It has been split in such a way because some students have chosen not to use the iPads. The way the groups are split change. This is because the groups have to be the same size for the statistical significance tool to work. The students are hereby exposed to four different conditions.
The experiment is conducted in a split plot scenario because someone who has used the program for 10 hours, cannot possibly be in the group that has used them with low frequency. The students are either in Low or High frequency, but cannot be in both. This creates a between-group position. Since the tests are created with a before and after result, the conditions force the participants to be in both groups. This effectively means that there is a within-group position for these students as well, creating a split plot scenario.

Participants:

The units of the analysis as named in the case study, or participants as it can be called in Experimental research – are the students and to some degree the teacher.

The students: The 27 students using the classroom, were now in the 9th grade by Norwegian school standards, still corresponding to junior high. This means they were around 13-15 years of age at the time the case study was conducted. The students were the same as those seen in the case study. The same 11/16 split of genders was still present as well. This time perhaps a bit more proficient in iPad

use, a bit smarter (or at least older) and quite a bit friendlier.

The teacher: The teacher was presented in the case study section and not much has changed. He was experiencing some health problems this semester, which might have had some impact on the study. This however is difficult to take in to consideration.

The normal classroom situation: By this time, some teachers had discussed this class as they had some issues with the students. It was made clear by several teachers that this class featured some of the noisiest, unwilling students at the whole school. Labelled as here-say it was a bit difficult to grasp just this, but their teacher verified the rumours when asked about his. He however explained that in his classes he did not experience the trouble most other teachers did – and neither the researcher. This information is only mentioned, as it might have some impact on the study. This impact cannot be proven directly, but if the study was to be replicated it could be a factor. It could have impacted the students either way, as the motivation created from the variation of teaching could be much more powerful to these students. It is a variable that is hard to define the impact of. A last bit of change is the installation of projectors in the classroom.

The new classroom situation: Unlike last semester, the students this time around were only guaranteed use during math classes. The use was limited by their mathematical insights and a wish for the students to progress normally in the game – resulting in the same students using the same iPads two classes in a row. This way they would be able to continue on their previous save. There was expressed a wish for Wi-Fi on these tablets, but during the few months it had been since the last case study, the school had found it necessary to create some new policies. These effectively restricted student access on devices such as cell phones, laptops and tablets. The equipment owned by the school was approved however, but tablets were seen as a risk. The IT administrator said that it was too easy to find the password for the Wi-Fi on these devices.

Data analysis plan:

The qualitative data sources were observations and interviews. Content analysis was used to analyse the interview data. Quantitative Data-gathering was done in the shape of mathematical tests where the students had one prior to DragonBox use and one post. These are all explained below.

Observations:

The observation was not a primary goal for the experiment, but curiosity was largely a determiner when deciding this method would be used. Insight to use and enjoyment of the application is the primary argument for the validity of this method. The observations were in this case done in a more participatory approach. From this it was hoped to find out what they were doing and why. Insight to how they felt about this game, and how they played it was wanted. What was not planned however, was that the teacher was not present. It later turned out that this is how the teacher was actually teaching the students with the iPads. It was in this case a direct observation, with structured segments focusing on the use of the iPad, and the general motivation of the students. There were no tools or measurement involve in this observation, giving it the casual trait.
The framework for what was observed was inspired by the classroom ecology presented in the case study chapter and use the schematic diagram (Figure 3) as a foundation.

Interview

45 minutes was again given to interview the students. From the case study responses, this was adequate. Three students were together in a group. Four groups were able to answer the questions, making it 12 out of 27 students at an estimate of about 12 minutes each (with some overtime and delay). The same routine was followed when interviewing a second class, wanting to gather insight from students at the same level which have not experienced the tablets.
As was the case in the case study, these group conversations might have led to some bias in their answers. This was however expected and attempted avoided by rephrasing the questions slightly, asking about further insights to the same question, and asking different students to answer first.
The interview followed a set amount of questions, but was open to deviate when new and interesting topics were brought up. This did happen quite often, though most often what they answered were questions planned later in the schedule.
Further, they followed quite closely the aspects suggested in Lazar et al(Lazar, Fen & Hochheiser, 2010) which says the following; *"HCI researchers use interviews and focus groups to help build an understanding of the needs, practices, concerns , preferences and attitudes of the people who might interact with a current or future computer system."* (Lazar, Fen & Hochheiser, 2010). Attitudes, preferences, and concerns were in high interest for the motivational aspect. Practices and needs come in close second. The interviews were voice recorded, and transcribed for the main class, but only notes were available for the second class.

Content Analysis:

The interviews from the main class is analysed through content analysis. The interviews have been transcribed and placed in to categories which the supervisor has assisted with. The categories will be presented to increase the validity. The reliability of the data will be looked at with the use of an agreement matrix / Kohen's kappa.

The tests:

The point of these tests were to see if one could improve the results from the students with the use of the iPad, and the game application centred around the algebraic aspect of maths.
This aspect strictly measures the progress of learning for the students, with the minimum amount of bias. It was planned to compare this aspect with another class. It is to some degree compared, but the idea of bias from many sources advocate that the main test should be compared within the same class. This is because these students have the same amount of mathematics classes, same teacher, same classmates, and same opportunities. Their results can however still be interesting when comparing the two classes. Both classes had curriculum unrelated to the algebra found in DragonBox at the time of the testing.
The first results were from a national test before the experiment where the algebra related equations had been taken from the tests and their results had been noted down on a list for every student. The second test was created by the teachers of both classes and based on the same type of questions as the previous test, though with different numbers. The first test offered 17 possible points, and the second offered 11. A percentage amount was used to compare the total outcome of the tests. On the tests they were given boxes to check how much they had played DragonBox during the semester. The curriculum for the period of the experiment did not include algebra, but the students were required to hand in correction of the first test after it was taken. This was the only algebra they were exposed to in this period, not counting that which DragonBox was responsible for. Some improvement is expected from the correction of their tests in all the results (both classes). Only 18 students volunteered in the control class to take the test, while 27 students took the test in the experiment class. The information was first treated in excel, and rows with participants, results and use-time was created. Means were compared and a statistical significance tool was used to check the data.

Post exposure tests can be found in the appendix (Appendix # 4), but pre-exposure tests are not included due to these being a part of national tests.

Statistical significance tools:

Looking at the Variables and Conditions earlier defined in this chapter, there are two independent variables. These independent variables create four possible conditions. According to Lazar et al (Lazar, Fen & Hochheiser, 2010)), the needed tool for a significance analysis is therefore a Split-Plot ANOVA. The split plot ANOVA used, is the Repeated Measures ANOVA in SPSS.

5.4 DragonBox+

Background information

The application in the centre of the experiment is named DragonBox+. For simplicity, it will be referred to as DragonBox. The application is to a certain degree classified as a game. This is because of the many aspects of gamification found in the application. The purpose of this application is to teach people algebra. The application was released on the 8th of May, 2012[10] by the company WeWantToKnow. Since launch, they have received positive feedback from many sources. One of these sources is the forum on their web page. Here we can find quotes such as: *"From our studies at "Nittedal Videregående skole" we have seen that game based learning has a huge potential with endless possibilities for creativity, problem solving and collaboration. DragonBox has been tested in our school with very positive results [translated]".* [11]Most of the feedback on the page evolve around younger kids around the age of 8, learning complex algebra. Very recently, the company behind this application released a new version of this game, and they now offer two variants. DragonBox algebra 5+ and DragonBox Algebra 12+ despite the tested version currently being the only available app at the time of writing (10.06.13).
One might question how this game will fit students at the age of 13-15, which is the case of the experimental research conducted in this thesis. The first quote listed from "Nittedal" includes students a few years older than this. Another quote states that this application contains concepts the reviewer found hard, at a time period of 14-19 years of age. This is not in any way evidence that this application is the best suited for the project, nor that it will be successful, but it does leave curiosity and a firm belief that this application might just have what it takes.

---

[10] http://dragonboxapp.com/changelog.html (Last consulted 11.09.12)

[11] http://dragonboxapp.com/quotes.html (Last consulted 11.09.12)

The quotes and testimonials from their web pages is however not the only source of information. This application has received remarkable reviews and lot of news-coverage from Norwegian papers. Reviews from before the name-change show:

The iTunes store[12] has the application for sale, with a 5/5 star ranking, and 390 ratings.

The Google store [13] display this application with 5/5 stars, and 195 ratings.

Media coverage

The game has been featured in several Norwegian newspapers and online sources which offers videos of the game. Amongst these are;

http://www.aftenposten.no/nyheter/iriks/Tallentet-6968364.html

http://www.aftenposten.no/webtv/Larer-algebra-med-app-6827001.html

http://www.dagbladet.no/2012/06/03/kultur/analog_digital/spill/app/ios/21843757/

http://e24.no/kommentarer/nettrevolusjonen-innen-utdanning/20294109

These URLs were checked on the 2nd of May 2013.

In a newspaper article published may 5th [14]the prices won by this application are displayed. The newspaper has some errors, but this list should be the correct version:

- *Best of show* and *Best serious game for home learning* – International Serious Play Awards 2012 at The International serious play conference
- *Children's application of the year* 2012 – from Gulltasten [translated]
- *Application of the year* 2012 – from Gulltasten [translated]
- *Best serious game for education* – Bilbao Fun and serious game festival 2012
- *Best Game Mobile Category* –Serious Games Showcase & Challenge 2012 from the Interservice / Industry Training, Simulation and Education Conference (I/ITSEC).

12 https://itunes.apple.com/us/app/dragonbox+-algebra/id522069155?mt=8 (Last consulted 02.05.2013)

13 https://play.google.com/store/apps/details?id=com.wewanttoknow.DragonBoxPlus (Last consulted 02.05.2013)

14 http://www.aftenposten.no/kultur/Leker-seg-gjennom-mattepensum-7193134.html (Last consulted 02.05.2013)

- One of the winners from 2013 ON for Learning Award by Common Sense Media.
- *Best serious game* – International Mobile Game Awards 2013
- *Best Nordic Innovation Award 2013* – Nordic Game Conference

How does the application work?

To explain best how this application works, a series of screenshots from the game can illustrate. The first (Figure 10) demonstrates how you win this game. Sometimes there is a box like the one illustrated and sometimes it is displayed as X.

Figure 10. This figure shows the way to win in DragonBox.

A tutorial takes you through the steps slowly with how you use positive or negative versions of the boxes, multiplications, division and additions.

Figure 11. This figure illustrates an interaction which will remove two boxes.

In Figure 9, a positive box is placed on a negative so they even each other out.
The mathematical comparison for this would be that 5 and -5 equal each other.
This is just the beginning however, and the equations become more advanced quickly.

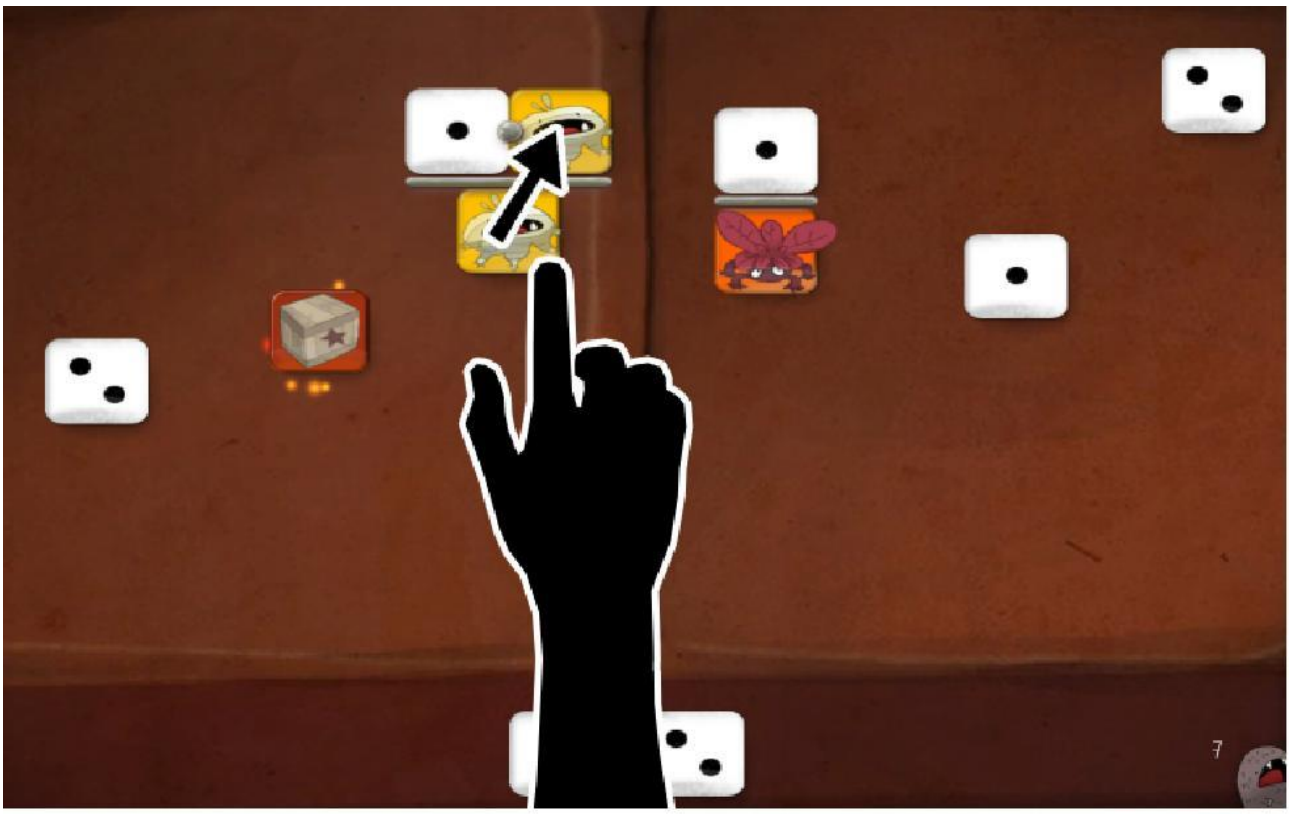


Figure 12. This figure illustrates a more complex level and an interaction between identical icons

In Figure 10 you have multiplication and division. Two similar icons above and below the line of division means that can cancel each other.

The equations become highly advanced in the end, and pictures are replaced with numbers and letters to more closely resemble that of normal algebra. The last level when not counting the bonus levels, looks like Figure 13 when you start, and at the end it will look like picture Figure 14

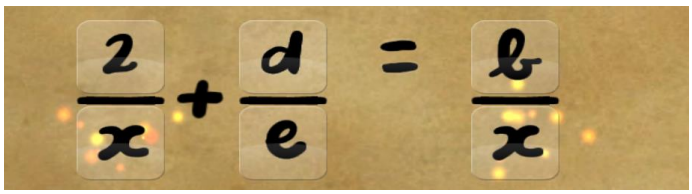


Figure 14. This figure shows the start of the last level (not bonus levels)

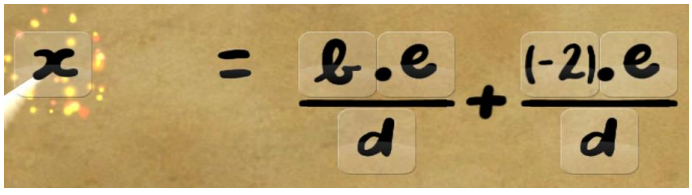


Figure 13. This figure shows how Figure 13 is when finished..

Relation to algebra:

The theoretical framework behind the game is closely related to real algebra. It teaches you the order you have to "move the boxes", adding "boxes" to all sections of the equation, and all the fundamental aspects of algebra. It goes through additions, multiplications, divisions and everything in between for equations in algebra, where the main point is teaching the students the order of which they are done in a repetitive manner.

Motivational aspects:

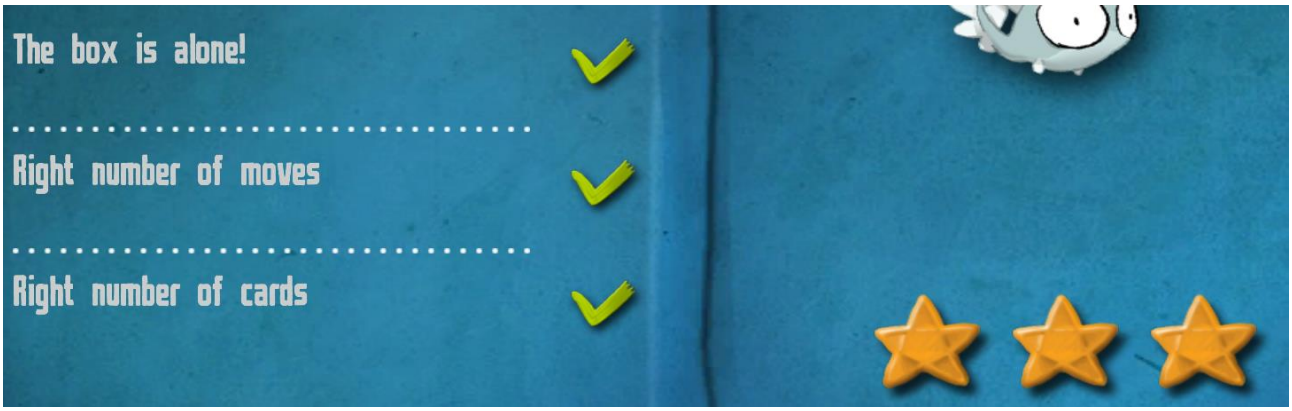


Figure 15. This figure is an overview of gamification aspects in the application.

For every level there are the same goals. These are seen in Figure 13. There are the minimum amount of moves you can do to handle the equation, and the right number of cards on either side – meaning you have removed all the parts of the equation you can move. The first goal has to be achieved in order to pass the level. In Figure 15 there is a small creature. This creature evolves with your progress. When you have completed all the equations for the different levels, this monster will have evolved fully to display a menacing creature. The purpose of getting all these stars is to unlock the hidden levels at the end, but they are very visible throughout the whole game. From what the researcher has seen, there are no achievements for the game that can be unlocked for the progress, but there are ways to share your progress through Facebook. In addition, the player selects an avatar to play through the application with. Some of these are shown in Figure 16. You cannot customize the avatar, but there are a few available. Two additional images showing interaction with DragonBox and the teachers iPad are found in the Appendix (Appendix #5 and Appendix#6).

Figure 16. This figure displays some of the avatars.

5.5 The data collected during the experimental research:

The data from the different research methods are presented in this section. This includes observational notes, interview data and math tests. There are categories after each point, which is created to illustrate how the answer relates to a bigger picture.

Observations

From the observation held in the classroom, the following important notes are presented:

- An impression of wide variety was had when first observing the application. The students were at very different stages in the application. (Aspects noted of interest relate to quality of game)
- In the observations, the starting levels looked little complex and it slowly increased this difficulty. The first levels generally took the students a few seconds to complete. (Aspects noted of interest relate to difficulty of game)
- Some students find it difficult, but these have progressed far beyond the first levels. They look at the icons and move them around, but do not grasp the order in which to do this. (Aspects noted of interest relate to difficulty of game).
- Seeking out other students for a helping hand was a common occurrence after most students have progressed beyond the first levels. (Aspects noted of interest relate to social collaboration).
- It is often observed cases where students receive help, but the help given is a flicker of the hand to solve the equation. The students who help them offer little to no explanation.

(Aspects noted of interest relate to social collaboration, or perhaps lack of)

- Getting stuck while trying to solve an equation was frequent. Some students are hesitant to ask others for help and would rather try the equation over and over. A student was observed trying five times without asking anyone. (Aspects noted of interest relate to difficulty of game)
- Most students sit at their own desks, but some sit in groups of two. All students sit close to someone else as a standard layout of the classroom, but those who sit in groups are sharing desks. (Aspects noted of interest relate to social collaboration / role of technology).
- Out of a current class of 16 people, 4 share iPads.
- The teamwork is only conducted one way. it is done in a manner where they solve one puzzle each. (Aspects noted of interest relate to social collaboration).
- Those who own the game show a greater interest in “stars”, than those who borrow the device. (Aspects noted of interest relate to gamification elements).
- The class was surprisingly calm and quiet, considering previous experiences. There are only 2-3 people which make noise, while the rest are quiet and focused. (Aspects noted of interest relate to tablet effect on class)
- As some people finished playing through the application the students stopped using the application and focused on talking with other students. There was little interest in playing again for those asked. (Aspects noted of interest relate to motivation).
- This is not the case for all students. Later observed, one student explains when asked that he would rather sit and play through the game again, rather than have normal maths. (Aspects noted of interest relate to motivation)
- Throughout the entire observation the students were never caught using other applications. (Aspects noted of interest relate to tablet effect on class / motivation).
- It is less rewarding to share the iPad based on expressions and attitude. The students who shared were less immersed in the application and spent half their time glancing over at other students. (Aspects noted of interest relate to motivation)
- The students who were making a disturbance were either stuck in the middle of a puzzle or the students who had finished the game. (Aspects noted of interest relate to tablet effect on class).

Interviews

The interview with the class which was experimented on, will be analysed through content analysis. The second interview with the control class has only been summarized due to issues with consent forms and ages that prevented recording of the interviews.

Interview with control class:

Data from the interview with the control class show:

- *When asked about their impression of the math subject*, the replies ranged from very negative to very positive. One student found the math topic very frustrating while most other students were either neutral or positive. (Aspects noted of interest relate to impression of maths subject).
- *When asked about the devices the students own,* they explained that all had smartphones which they brought to school. None of these were mentioned used during class. Tablets are owned by half the students asked. (Aspects noted of interest relate to product ecology).
- *When asked if the students had tried games connected to education*, most students had not thought about educational games. They asked for clarification as to what can be described as an educational game. From this it was learned that half of the students had played one at one time or another, but did not specify platform. (Aspects noted of interest relate to interested in educational games).
- *When asked if they knew about DB (DragonBox)*, nearly all students said yes and were familiar with the project in the other class. However, only three of the students had looked in to the application. (Aspects noted of interest relate to lack of interest).
- *When asked if they had played DB*, most students explained that they did not have time or interest. “Don’t know” was a popular answer. The students who had tried were not impressed by it. (Aspects noted of interest relate to lack of interest / difficult to understand potential).
- *When asked about ideas for better maths classes*, the students had few suggestions on what could change for the students to better enjoy them. The only two variations in addition to “no” were “variation” and “too much theory”. DragonBox was mentioned as something they could be interested in to get a more varied class. (Aspects noted of interest relate to

motivation to play / Impression of maths).

- *When asked about their feelings towards group work,* some students shrug and others explain that there is some. Three students explain that there is a lot of group work. (It was attempted to gain insight to social collaboration).

Interview with main class:

The students from the iPad enhanced class had the following to tell during the interview:

- *When asked about their experience with the maths subject*, the students explain they are fond of their teacher. Their responses go from challenging, hard, difficult - to good, "learning a lot" and fun. One student says that the subject is incredibly hard when she does not understand the math, but incredibly easy (and fun, later explained) when she does. Algebra is several times mentioned as difficult. (Aspects noted of interest relate to student relations to maths and algebra).
- *When asked if the students had played DB*, all but one of the interviewed students had played.
- *When asked where they had played DB*, the students mostly answered at school. Some students had played at home or other places. Three student said they had played through the whole application on their cell phones. One explains that he plays DB as a normal game when he's home. (Aspects noted of interest relate to situation / interest).
- *When asked how much time they have spent on DB*, the students give wide answers often ranging several hours between the lowest possible playtime and the highest possible playtime. (Aspects noted of interest relate to accuracy of data).
- *When asked about the difficulty of DB*, the students generally agree that the start of DB is easy and that the progress becomes challenging. One student explains that when the icons switch to letters, the game becomes a lot harder. (Aspects noted of interest relate to difficulty of application / Harder when it is related to real mathematics).
- *When asked if playing with maths is better*, the students generally agree this is the case. One student says it is fun and that he feels it is beneficial to his learning. He further explains that he "learns by doing" (translated) and that he likes learning in a fun way. Fun with variation was also a reply. (Aspects noted of interest relate to motivation).
- *When asked if the application is cool*, the students agree that it is. Some say "more fun than

maths". Two students said they had more motivation to play DB than they did for the maths class. (Aspects noted of interest relate to motivation).

- *When asked about playing with other students*, the students explain that the class is mostly split up when they play. That way the students who play will sit together and the students who do not are not disturbed. The students like it this way, as they can ask fellow students when they have trouble progressing. (Aspects noted of interest relate to tablet effect on class / social collaboration).
- *When asked if they needed help while playing,* the students admitted that at one point or another they had struggled, but only some had asked for help. Those who did not had kept trying till they made it. (Aspects noted of interest relate to difficulty of app / social collaboration).
- *When asked if they think it helps to be good at maths when playing DB*, the students mostly agree that it can help to be good at math. Some explain that they managed to help other students who were better at math and that they therefor believe it does not have much to say. One student says that he thinks those who are good with algebra will have an easier time with the application. They are very vague and unsure while answering this question. (Aspects noted of interest relate to motivation / relation to maths).
- *When asked if the game is better played alone or together with someone*, students say alone. They do however clarify that they like to play together with their fellow students – just on their own iPad. One student explained how he had competed against a friend with the levels in the game. (Aspects noted of interest relate to motivation / Role of technology).
- *When asked how big the groups should be*, the students range from two to five students. They do however explain that they have been as many as 15 and that this worked alright. (Aspects noted of interest relate to limits to social collaboration).
- *When asked about how many times they have played through* DB, student answers range from none to three times. One student proudly explained that he had played through the application three times and the other students said "wow". He further explained how he had gathered all the stars and completed all the bonus levels. (Aspects noted of interest relate to motivation / Interest in game).
- *When asked about the stars in the game*, the students explain they mostly attempted to get all stars until the difficulty was so high that they would be happy with any number. Some

students explain that they kept trying till they had them all. (Aspects noted of interest relate to gamification elements).

- *When asked if they were interested in sharing their results from DB*, none of the students were particularly interested, but some explain they would recommend the application to others. (Aspects noted of interest relate to Cool factor).
- *When asked about the role of the teacher as the class played DB*, the students explained that he remained in class with the students who had trouble with homework. One student explained that he once offered special education for the next grade to those interested. One student said he does not do much. The students further explain that the teacher sometimes comes in to watch them and make sure they are doing what they are supposed to. Some students explain that there is a lot of noise with the large groups and no teacher present. In addition, they say that cell phones are often used to kill time through Facebook and similar sites during this time. (Aspects noted of interest relate to role of teacher / effect of iPads / issues with monitoring).
- *When asked if they think they learn something from DB*, the students are mostly hesitant to answer. Some students say yes immediately while some see it as a fun learning strategy. They do however agree that they would prefer to have the game and its relationship to algebra thoroughly explained, as it was not easy to comprehend. (Aspects noted of interest relate to maths being hard to grasp / Motivation to play).

Math test:

This section will provide all the data gathered from the math tests, which will be looked at in greater detail under "summary and analysis".

Class with-out iPad	PRE	POST
Student 1	64,71%	100,00%
Student 2	17,65%	18,18%
Student 3	47,06%	63,64%
Student 4	47,06%	63,64%
Student 5	23,53%	27,27%
Student 6	41,18%	72,73%
Student 7	29,41%	63,64%
Student 8	76,47%	54,55%
Student 9	52,94%	45,45%
Student 10	23,53%	27,27%
Student 11	76,47%	54,55%
Student 12	47,06%	54,55%
Student 13	47,06%	36,36%
Student 14	35,29%	63,64%
Student 15	32,35%	45,45%
Student 16	94,12%	72,73%
Student 17	58,82%	45,45%
Student 18	70,59%	72,73%

Class with iPad	PRE	POST	DB TIME
Student 1	64,71%	100,00%	3
Student 2	52,94%	54,55%	1
Student 3	58,82%	100,00%	5
Student 4	41,18%	63,64%	2
Student 5	70,59%	100,00%	10
Student 6	41,18%	81,82%	2
Student 7	58,82%	54,55%	2
Student 8	52,94%	63,64%	5
Student 9	23,53%	54,55%	5
Student 10	35,29%	90,91%	5
Student 11	17,65%	54,55%	3
Student 12	14,71%	18,18%	0
Student 13	23,53%	54,55%	2
Student 14	64,71%	63,64%	2
Student 15	70,59%	100,00%	1
Student 16	58,82%	54,55%	10
Student 17	100,00%	100,00%	2
Student 18	76,47%	100,00%	1
Student 19	35,29%	36,36%	2
Student 20	23,53%	54,55%	1
Student 21	17,65%	27,27%	0
Student 22	52,94%	72,73%	3
Student 23	47,06%	54,55%	0
Student 24	29,41%	90,91%	3
Student 25	58,82%	63,64%	1
Student 26	100,00%	81,82%	1
Student 27	23,53%	45,45%	3

Table 4. Complete list of results from experiment

Summary and analysis:

For the iPad enhanced class interviews, the content was analysed according to meaningful categories, which were defined from the interviews and the related literature. The interview with the control class was simply summarised, as were the observations from the study.

Summary of observations:

A summary of the observations show that the difficulty of DragonBox progressed well. Students were seen enjoying the early levels and struggling at the end of class. The difficulty forced students to seek help from fellow students. Most students did this, but some chose not to. The students who did not seek help were seen attempting the levels over and over on their own. The social collaboration aspect was seen between some students who used the same iPad. These were less content and noisier than the other students. The class as a whole were observed to be quieter than last semester. The students who brought their own devices to class were more interested in the gamification aspects of the game such as stars. Lastly, there were no other application seen used during the observations showing that the game managed to keep their interest. Some students trailed off at the end of the class, but they were being loudly social instead of playing other applications. The students who did this were either stuck on a puzzle or finished with the application.

Summary of interview with control class

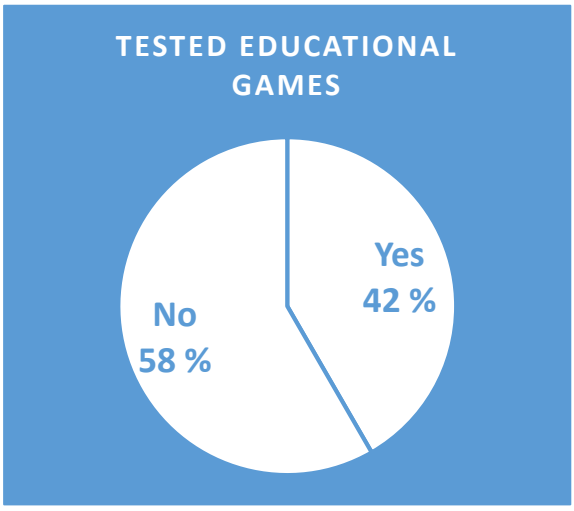


Figure 18. This figure shows how many students have tested educational games.

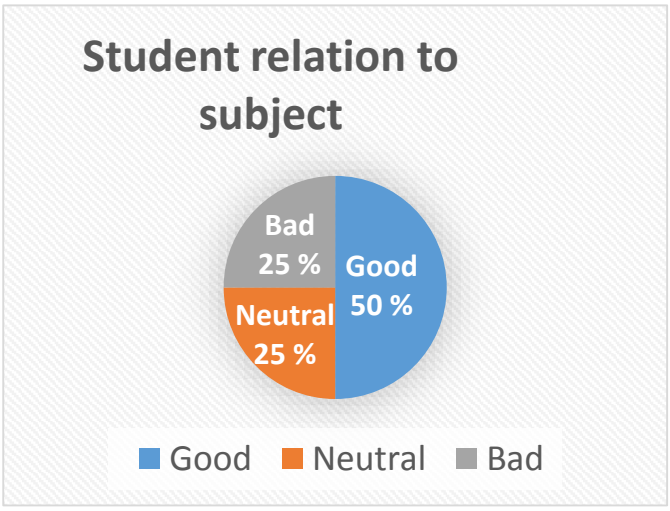


Figure 17. This figure shows student relationship to math subject.

The interview with the control class is not mainly in focus, but can be seen as a way to increase understanding around a phenomenon based on fellow students. There is a lot of bias when having different classes, different students and different teachers. This is the reason the information cannot be directly compared to the primary class. This interview differs from the other due to the strict structure. There is no deviation from the questions, and no additional questions. Because of this, the results from the interview will be presented in graphics and by qualitative data – representing similarities to a questionnaire. Figure 17 shows the student's relation to the math subject. Here we see that half of the students are happy with the subject. What we also see, is that 25% of the students dislike the math subject.

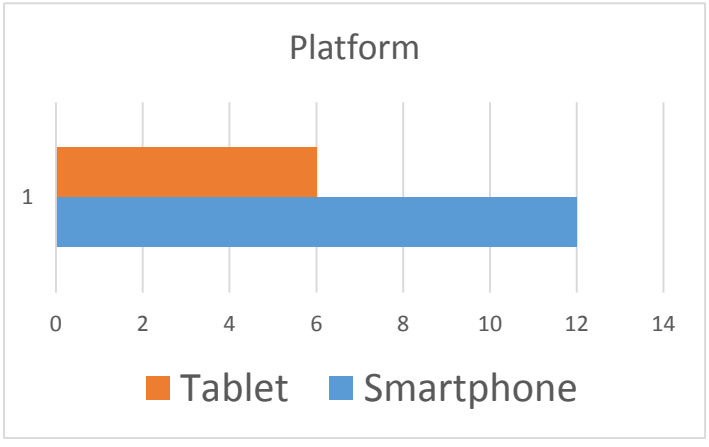


Figure 19. This figure shows which platforms the students owned.

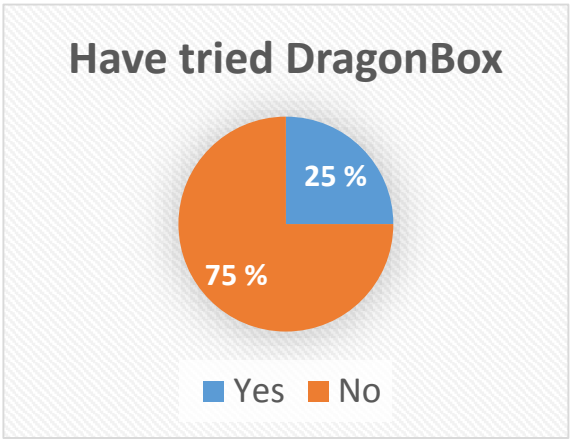


Figure 20. This figure shows that one in four students in control group have tried DragonBox.

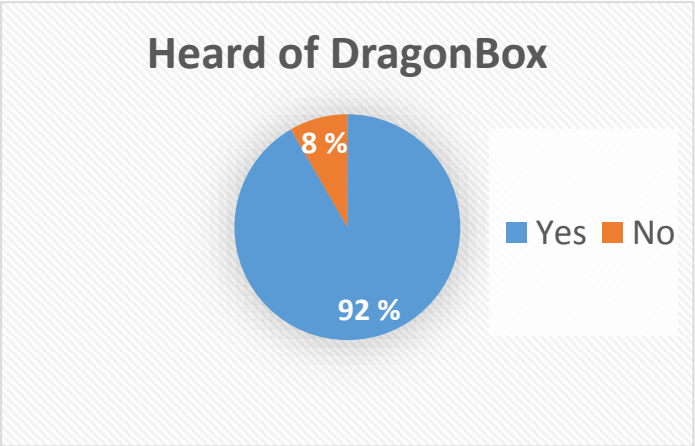


Figure 23. This figure shows most students in control group knows of DragonBox.

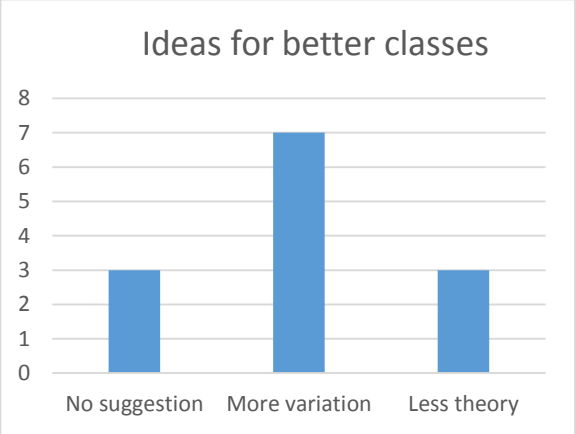


Figure 22. This figure shows that most students want the math classes to change.

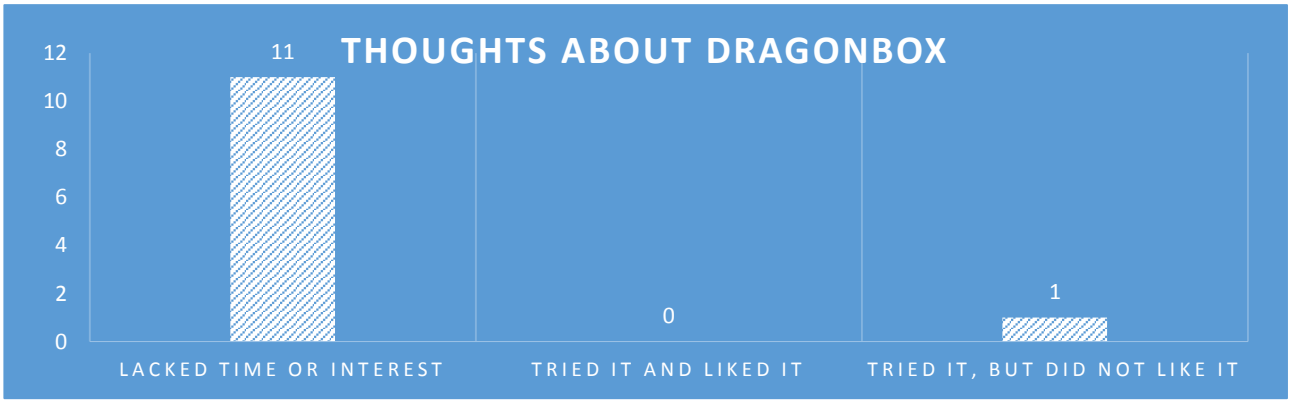


Figure 21. This figure shows a lack of motivation for trying DragonBox.

The students were asked about which platforms they used and owned. 100% of the students asked, had a cell phone. Half of them had a tablet available. This is illustrated in Figure 18. In Figure 19, the students were asked if they had played some type of educational game before, on their own. 42% of the students asked had actually done this.

It was suspected before the comparison between the classes, that some of the students would be inspired to try DragonBox, as they knew they were going to be compared with the other class. 10 out of 11 students had heard about the program from either the teacher or the fellow students. This is illustrated in Figure 20.

The name of the game spreading to the students is understandable. From this knowledge it was likely that some of the students would have a look in to the application. 50% had tablets, but all had

cell phones. According to iTunes[15], this program can run on cell phones as well. According to the DragonBox webpage[16], it will run on almost anything (except windows phone 8). This means nearly all students should be able to play this application, yet from Figure 21 we see that only 25% have.

Only three students have tried the game, out of twelve. The logical next question was to find out why the students had not played it, and what the students who had tried it thought about DragonBox. There were three students who had tried the application, and from Figure 20 we see that 11 of 12 students lacked either time or interest to play DragonBox. Two of the students who claimed to have played the application is listed here as well. One student (33% of those who tried it) claimed that he did not like it. The last question they were asked was how their math class could possibly be improved. There were no suggestions to the students made about how it could be, but their answers were grouped as shown in Figure 21. Variation is the most popular suggestion, and less theory is tied with the students who did not have any ideas on how it could be better – or which found the classes good. What we see is that 10 out of 12 students would like a change in their math classes, and 7 out of 12 would like more variation in their learning.

Content analysis of interview with DragonBox enhanced class:

Creating the categories and a coding scheme for the content analysis:

Together with the supervisor of this thesis, parts of an interview was investigated and a coding scheme was developed. Two separate coding schemes were created, to increase the reliability of the categories. From the categories, new emerged with wider terms. These terms have foundations in the literature. The titles in parenthesis, are the original names used by either the researcher or supervisor. These have then been merged to create the wider terms.

Time *(time used / time)* – This category refers to the time the students had spent on the application.

Situation ***(****Group work/ location / Where and when)* –This category is created for the purpose of understanding where, when and how the tablet and application is used.

15 https://itunes.apple.com/us/app/dragonbox+-algebra/id522069155?mt=8 (Last consulted 22.05.2013)

16 http://support.dragonboxapp.com/knowledgebase/articles/84486-system-requirements (Last consulted 22.05.2013)

Teacher *(teaching / teacher /pedagogics)* – Information about the teacher and how he teaches

Motivation DragonBox *(enjoyment of / feelings related to use)* –Motivational aspects. This includes what the students get out of the use in terms of enjoyment and learning.

Difficulty *(Difficult / Feelings towards)* – This category describes the difficulty of the application.

Platform *(platform / technology /device)* – This term now includes all products mentioned by students.

Experience of math off tablet *(Math class / the students without tablet).* This category includes all interesting mentions from the students related to the math class experience. It can be seen as a "motivation" category but for the maths subject.

Findings:

The terms quoted in the following table has been translated to English.

Category	Finds
Time	- The aspect of time varied largely between the students, as such does the notion of accuracy. Most students were able to pinpoint the time spent with about one hour of leeway between the alternatives. Some were however surprisingly accurate and stated; "2 hours" or "3 hours". The answers ranged from 45 minutes to 5 hours. The researcher used the highest number from each reply to test against the average seen from what the students had answered on the tests. The result can be seen in Figure 26 and shows us that the numbers are very similar. This suggest many students might prefer reporting more than less of their actual use.
Situation	- Seven students explained to have used the application at home, one had used it on a plane, and nine explained they had used it during the classes. Figure 24 displays the typical places of use and popularity of such. - Other replies show that iPads have been used at home. Since the students were not allowed to bring the iPads home, this must mean that the students themselves often bought the application for private use. Some students expressed the time in math classes, which suggests they have only played it

	at school.
Teacher	- There was little feedback on the teacher. Students were mostly happy with their teacher. They say things like “explains easily” and “very good teacher” when describing him. - The students explain that he divides the classes in two – where he remains to teach those who do not play DragonBox. The group which remains are most often students that have a hard time with their maths. Sometimes he introduces new mathematics from the next semester for the students who are wanting to learn something new. - The students explain that the teacher checks in on the ones who use iPad. Another student says that if they had two teachers, it would have been a lot better. The reasoning for this is “less noise“. - A last note about the teacher is that he is “not good” with DragonBox.
Motivation	- There is an abundance of positive feedback when it comes to DragonBox. The students who have tried it often explain that is a very welcomed change. Some say it is better than normal maths. “Fun” and “better” are returning adjectives describing the student experience. - Most of the time, students refer to the use of DragonBox as “playing”. - There are some words that are only used when discussing games. The students used one of these words often when talking about the completion of DragonBox. The word they used was: “runnet” which means they have played it all the way through. Some however referred to the interaction between them and game as “used“, which is more in line of what one would expect from a typical learning application. One student used the expression “was allowed to use it“, giving the impression it was a perk (which it was). - “Variation” and “fun way to learn”, are two descriptions that have come up. One student says “it’s very different, so perhaps it gives us more

	motivation". - One student explained with great pride that she was able to help a student with the application which was a lot better than her at maths. When other students were asked about this, they said that being good at maths was beneficial to the use of the application, but not needed. - The topic of helping others came up quite often and most students explained that they at some point needed help. The students further explained that they preferred to have an iPad for themselves, but that they wanted to sit together with their fellow students, because it was "nice to ponder together" and to "compare". - Some students explained that they would play a game of DragonBox where they started on the same levels and the goal was to finish first with all three stars. - The stars motivated most students at the first levels, but as the equations grew more difficult they lost interest. - The motivation also covers issues that are demotivating. Such issues are the difficulties of comparing what one learns using DB to the field of mathematics. A very few students explain that they learn more from the application than from mathematics, but by far the most of them explain difficulties with understanding if they have become better at the math or if they have not. In addition they are worried because they do not understand how the game translates in to learning. - There was not a single negative review of the application.
Difficulty	- The difficulty of the application was in many cases described as "easy", "very easy" – even "very very easy". After the start however, terms such as "harder and harder" and "more difficult" were used by most students. - It became clear that the beginning of the application was easy. Most students also agreed that it took a turn for the more difficult after a few levels when new elements were introduced. The responses can be seen in Figure 25. - Some students asked for help and others explain that they kept trying till they

	made it. One student explained that it is a very well made program due to the progress in difficulty and challenge. - There is a very general agreement between the students about the difficulty.
Platform	- Cell phones and iPads were frequently mentioned. The iPod had one mention. The word tablet was not mentioned once. Figure 27 shows the frequency of mentions. - Laptops and computers were not mentioned at all, though knowing the application is available for such systems. iPads and cell phones were mentioned equally often and the students use these devices frequently. - The cell phones are mentioned used when iPads are not available. These devices cover much of the same purposes, but the students use both.
Experience of math off tablet	- The students had a positive impression of their maths classes. In contrast to the description regarding DragonBox, the responses were not as positive. The students used expressions such as “pretty good“ and “alright“, as well as “fun“ and “good“. One student expressed his experience with the math as “very good“. The lessons are expressed to be good and to teach them a lot. Figure 28 illustrates the responses. - The difficulty of the math was an issue for many students, but they explain that when they understand the math, their enjoyment increases. - Some students explain that the noise level in class can be rather high, and another says that it is lower when they are in the group-rooms with DragonBox. - One student explains that she learns a lot more from the class because she sits next to someone that is very good at maths. She says that when she can get her fellow students point of view, things become easier for her and more enjoyable.

Additional information related to Content Analysis.

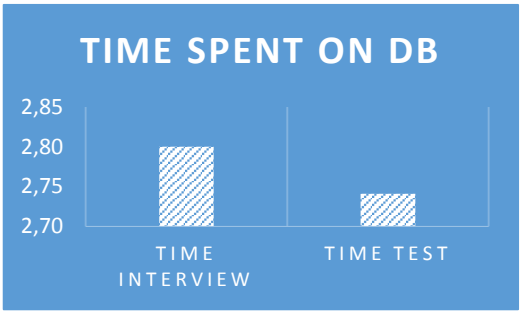


Figure 24. The figure shows the time students claimed to have spent playing DB.

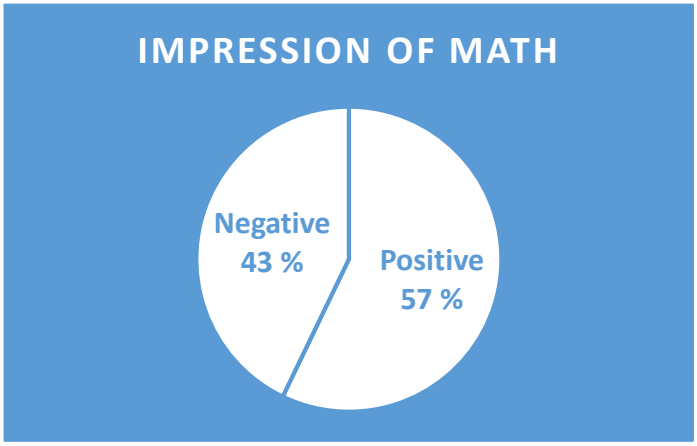


Figure 28. The figure shows student relationship with maths subject

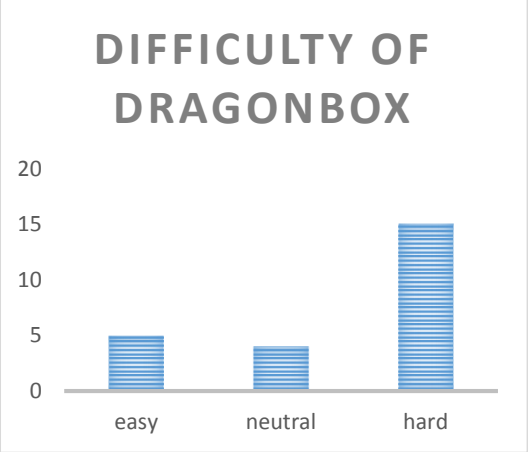


Figure 26. The figure shows feedback on the difficulty of DragonBox.

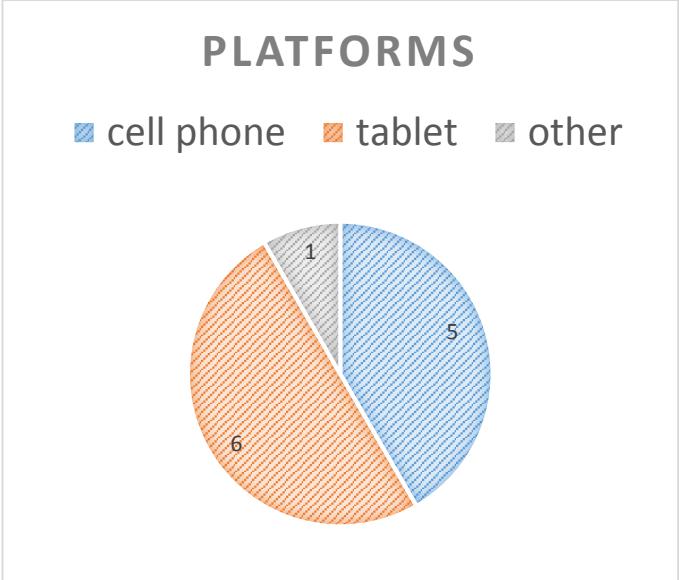


Figure 27. The figure shows that cell phones and tablets were the most popular devices.

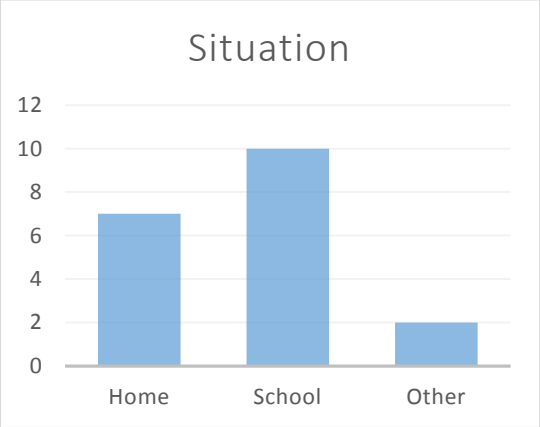


Figure 25. The figure shows the situations the students use tablets in.

Coding consistency:

	Time	Situation	Teacher	Motivation DB	Difficulty	Platform	Off tablet experience	
Time	4 (0.50)	0 (0,88)	0 (0,25)	0 (1,38)	0 (0,63)	0 (0,25)	0 (0,13)	4
Situation	0 (0,88)	7 (1,53)	0 (0,44)	0 (2,41)	0 (1,09)	0 (0,44)	0 (0,22)	7
Teacher	0 (0,25)	0 (0,44)	2 (0,13)	0 (0,69)	0 (0,31)	0 (0,13)	0 (0,06)	2
Motivation DB	0 (1,75)	0 (3,06)	0 (0,88)	11 (4,81)	3 (2,19)	0 (0,88)	0 (0,44)	14
Difficulty	0 (0,25)	0 (0,44)	0 (0,13)	0 (0,69)	2 (0,31)	0 (0,13)	0 (0,06)	2
Platform	0 (0,25)	0 (0,44)	0 (0,13)	0 (0,69)	0 (0,31)	2 (0,13)	0 (0,06)	2
Off tablet experience	0 (0,13)	0 (0,22)	0 (0,06)	0 (0,34)	0 (0,16)	0 (0,06)	1 (0,03)	1
	4	7	2	11	5	2	1	**32**

SUM Agreements=	29
SUM of frequency=	7,44
Evaluation Kappa=	0,88

Figure 29. This figure shows the calculated agreement matrix for this content analysis.

Same process was used as seen in the case study. An agreement matrix (Figure 29) was created to show the agreements between the coders. The categories had this time been created with the help of the supervisor, and so when the coding was compared between her and the author, the Kappa was 0,88. This number is more than satisfactory.

Mathematics tests:

The results from the ANOVA is first looked at to find out if there is a statistical significance to the differences between the conditions. After this, the data is more closely examined and compared.

Statistical significance tests

The ANOVA tests, also known as the statistical significance tests were run on the different groups which were split in equal sizes. This meant that the high and low frequency groups had to be adjusted after the amount of participants which were in them. They were sorted in two groups: "3-5 hours of use vs. 0-1 hours of use", which included 18 participants (9 in each). The next group was "5-10 hours of use vs. 1 hour of use" which included 12 participants (6 in each).

3-5 hours group against 0-1 hour group:

The tests indicated that there was a significant difference between pre and post-tests with: ($F(1, 16) = 35.69$, $p < 0.001$). This means that the students had clearly learned more after the first test. The interaction between DragonBox use and the pre & post-tests was also significant: ($F(1, 16) = 10.55$, $p < 0.05$). This means that DragonBox had a significant difference on the results. Information from the SPSS test is available for closer investigation below. Figure 30 show the means at the start and at the end of the experiment shown with the interaction of DragonBox. This shows us that the students who frequently used DragonBox were generally weaker than the other students, but that their final results (in average) were higher. Table 2 is a print from SPSS which display much of the extracted data.

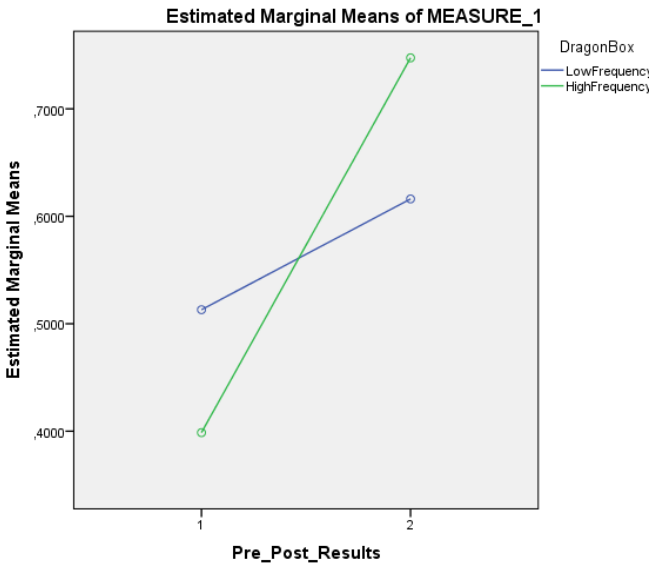


Figure 30. This figure shows the progress of high and low use for the 3-5 vs. 0-1 hour groups.

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Pre_Post_Results	Sphericity Assumed	,459	1	,459	35,691	,000	,690	35,691	1,000
	Greenhouse-Geisser	,459	1,000	,459	35,691	,000	,690	35,691	1,000
	Huynh-Feldt	,459	1,000	,459	35,691	,000	,690	35,691	1,000
	Lower-bound	,459	1,000	,459	35,691	,000	,690	35,691	1,000
Pre_Post_Results * DragonBox	Sphericity Assumed	,136	1	,136	10,551	,005	,397	10,551	,862
	Greenhouse-Geisser	,136	1,000	,136	10,551	,005	,397	10,551	,862
	Huynh-Feldt	,136	1,000	,136	10,551	,005	,397	10,551	,862
	Lower-bound	,136	1,000	,136	10,551	,005	,397	10,551	,862
Error(Pre_Post_Results)	Sphericity Assumed	,206	16	,013					
	Greenhouse-Geisser	,206	16,000	,013					
	Huynh-Feldt	,206	16,000	,013					
	Lower-bound	,206	16,000	,013					

a. Computed using alpha = ,05

Table 5. This table shows the data used to present the statistical significance for the 3-5 vs. 0-1 hour group.

5-10 hours group against 1 hour group:

The tests indicated that there was a significant difference between "pre" and "post"-tests with: (F (1 , 10) =11.16, p < 0.05). However, the interaction between DragonBox use and the pre & post-tests was in this case not significant: (F (1 , 10) = 1.68, p > 0.05). This means that the differences we see can have been a result of random errors or sampling. Information from the SPSS test is available for closer investigation below. Figure 31 show the means at the start and at the end of the experiment shown with the interaction of DragonBox. Again this graph show us that the students who frequently used DragonBox were generally weaker than the other students, but that their final results (in average) were a little higher. Table 3 is an overview of the within subject effects and the interaction with DragonBox.

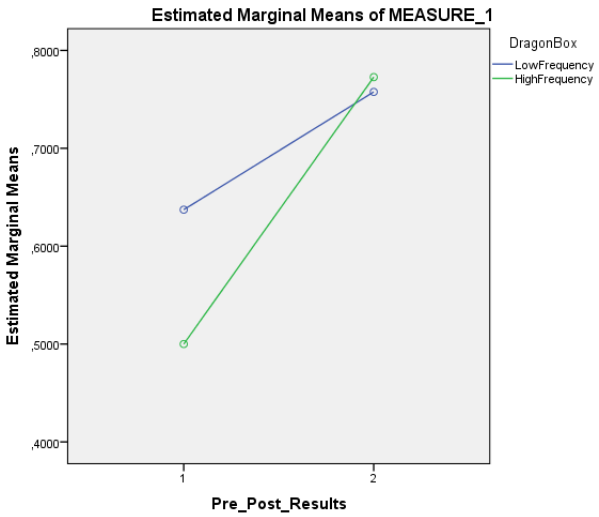


Figure 31. This figure shows the progress of high and low use for the 10-5 vs. 1 hour groups.

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[a]
Pre_Post_Results	Sphericity Assumed	,232	1	,232	11,157	,007	,527	11,157	,852
	Greenhouse-Geisser	,232	1,000	,232	11,157	,007	,527	11,157	,852
	Huynh-Feldt	,232	1,000	,232	11,157	,007	,527	11,157	,852
	Lower-bound	,232	1,000	,232	11,157	,007	,527	11,157	,852
Pre_Post_Results * DragonBox	Sphericity Assumed	,035	1	,035	1,678	,224	,144	1,678	,217
	Greenhouse-Geisser	,035	1,000	,035	1,678	,224	,144	1,678	,217
	Huynh-Feldt	,035	1,000	,035	1,678	,224	,144	1,678	,217
	Lower-bound	,035	1,000	,035	1,678	,224	,144	1,678	,217
Error(Pre_Post_Results)	Sphericity Assumed	,208	10	,021					
	Greenhouse-Geisser	,208	10,000	,021					
	Huynh-Feldt	,208	10,000	,021					
	Lower-bound	,208	10,000	,021					

a. Computed using alpha = ,05

Table 6. This table shows the data used to present the statistical significance for the 10-5 vs.1 hour group

A closer look at the results

A chart describing all results from the main class in the experiment is found below in Table 1. The brown line is the amount of hours they have spent with DragonBox. They noted this number down on their tests so they are directly tied up to each individual. “Test one” and “test two” on the left side refers to the first test and the second test. Test ONE is the test which occurred before they were introduced to DragonBox experiment and test two is the test which occurred.
The cells in test ONE corresponds to the same cells in test TWO. This means that the first cell under Ten - test one, which shows 70,59%, is the same student who scored 100% in test TWO.
The numbers in the tests are the percentages based on number of questions and points. This was done as the two tests varied in the number of questions and maximum points.

	Ten	Five	Three	Two	One	Zero
Test ONE	70,59%	58,82%	52,94%	41,18%	52,94%	14,71%
	58,82%	23,53%	29,41%	23,53%	70,59%	17,65%
		52,94%	23,53%	64,71%	76,47%	47,06%
		35,29%	64,71%	100,00%	23,53%	
			17,65%	35,29%	58,82%	
				41,18%	100,00%	
				58,82%		
Test TWO	100,00%	100,00%	72,73%	63,64%	54,55%	18,18%
	54,55%	54,55%	90,91%	54,55%	100,00%	27,27%
		63,64%	45,45%	63,64%	100,00%	54,55%
		90,91%	100,00%	100,00%	54,55%	
			54,55%	36,36%	63,64%	
				81,82%	81,82%	
				54,55%		
SUM ONE =	**48,69%**					
SUM TWO=	**68,01%**					

Table 7.This table shows all results from the main class.

Investigating the Excel table we see that nearly all results have a positive increase on the second test. We will not investigate the groups closer.

Group one:

Table 5 shows the table for this group. The intense green bar near the bottom is the sum of the improvement in each column. The green line at the very bottom, show the scores which are taken from the general average of test two, and subtracted the average from test one. This means that the group which has used this application from 3-5 hours, has nearly 35% higher average scores than

what they had previously. When investigating the group which has used DragonBox 0-1 hours, we see that one of these students have had a negative learning outcome. This in turn can affect the general outcome. Investigating the general results (Table 5) from comparing test one with test two, we can see that the results for the students with low use yield an average of only 10% increase. We do however note that half the students in "one hour" group see an increase of around 24-30%, while the other half has negative or little improvement. The results from the high frequency group is much more consistent in improvement.

Five	Three		One	Zero
58,82%	52,94%		52,94%	14,71%
23,53%	29,41%		70,59%	17,65%
52,94%	23,53%		76,47%	47,06%
35,29%	64,71%		23,53%	
	17,65%		58,82%	
			100,00%	
100,00%	72,73%		54,55%	18,18%
54,55%	90,91%		100,00%	27,27%
63,64%	45,45%		100,00%	54,55%
90,91%	100,00%		54,55%	
	54,55%		63,64%	
			81,82%	
34,63%	35,08%		12,03%	6,86%
Sum	34,85%		Sum	9,45%

Table 8. This table shows the comparison of improvement for the 3-5 vs. 0-1 hour group.

Group Two

The second group consists of six students under both conditions (shown in table 6). Here the 10 hour group and the 5 hour groups are represented, which should be the best representatives for the use as they are the students who have used the application most frequently. One of the students in the 10 hour group had a negative learning outcome and just like in group one there is a chance that this might affect the outcome. The 5-10 hour group had a over 23% increase in results. The group of students that have used DragonBox for one hour, had in comparison a close to 12% increase in results. This means the group with considerably more use, had 11% better results. The one bad result in the ten hour group is be the biggest reason for this not being higher.

Ten	Five		One
70,59%	58,82%		52,94%
58,82%	23,53%		70,59%
	52,94%		76,47%
	35,29%		23,53%
			58,82%
			100,00%
100,00%	100,00%		54,55%
54,55%	54,55%		100,00%
	63,64%		100,00%
	90,91%		54,55%
			63,64%
			81,82%
12,57%	34,63%		12,03%
Sum	22,06%		12,03%

Table 9. This table shows the comparison of improvement for the 10-5 vs. 1 hour group.

All groups:

Figure 32 is a diagram created to illustrate the differences between the groups. If we split the groups crudely down the middle and have the frequent users on one side, being 3-5-10 hours, and the non-frequent till no use at all on the right (0-1-2 hours), we get two uneven groups of students. The frequent group consisting of 11 students, and the non-frequent consisting of 17. The results listed is the average improvement for each group.

The results from the first test is subtracted from the results of the second test. This show us how much better (or worse) results the students have achieved. What we see is that there is a considerable difference between the two groups. The students who have used DragonBox frequently, perform remarkably better during the testing.

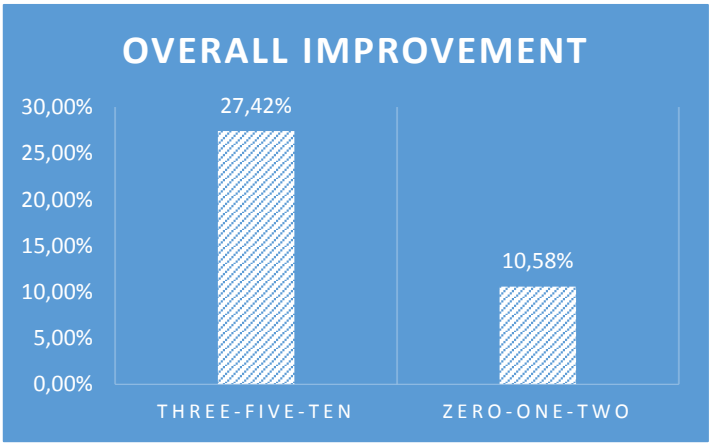


Figure 32. This figure compares improvement between high and low use of DragonBox.

One might attempt to find out why. One reason could be the different starting points. For example, if some students had 100% to start with, they could not improve. Both group one hour and group two hours have 1 student each with 100% on the first test, but they are the only. Alternatively, they could be considerably higher from the start, and perhaps thereby improve less. The general average of all groups for the first and second test can be seen in Table 7.

	Ten	Five	Three	Two	One	Zero
1	64,71%	42,65%	37,65%	52,10%	63,73%	26,47%
2	77,27%	77,27%	72,73%	64,94%	75,76%	33,33%

Table 10. This table shows mean scores for all groups.

This shows us that the means are vastly different between the groups. The group with one hour of use is very close to that of ten on both tests. It is difficult to directly compare them due to sample size and inconsistent results. Group one has results nearly twice that of group three from the first test, but the second test is very close. We see here that group three has more room for improvement than group one. Group five is lower than two and one as well, but their results exceed both groups in the second test.

These data are merely represented to get a greater understanding of the results, and to twist and turn as much as possible on the data for increased understanding.

One can also find some numbers of interest in the 0 hour section. Granted, these are under the same issues that the 10 hours group, with a lack of representatives. The difference however is that group zero has comparable progress which corresponds with the rest of the data. They have in addition had the smallest benefits to learning from this period – despite clearly having the most to learn. One can perhaps imagine that students with very low results are those who do not pay too much attention. However, they did take the voluntary test for this experiment.

The group with the far greatest improvements, is the three hours group. All of these students have around 20% improvement in their results, or better. Half of them are actually well above 30%.

Figure 30 is a graph with all the results to more easily see which groups improved the most:

Figure 33. This figure shows a graph over the results divided by hours of use of DragonBox

Comparing means with the control class

The two groups might not be very comparable due to the bias previously mentioned, but some aspects can be looked at and compared. The first we investigate is how the general results from the two classes compare.

Class without iPad	PRE	POST
Stranger 1	23,53%	27,27%
Stranger 2	76,47%	54,55%
Stranger 3	47,06%	54,55%
Stranger 4	47,06%	36,36%
Stranger 5	35,29%	63,64%
Stranger 6	32,35%	45,45%
Stranger 7	94,12%	72,73%
Stranger 8	58,82%	45,45%
Stranger 9	70,59%	72,73%
Stranger 10	64,71%	100,00%
Stranger 11	17,65%	18,18%
Stranger 12	47,06%	63,64%
Stranger 13	47,06%	63,64%
Stranger 14	23,53%	27,27%
Stranger 15	41,18%	72,73%
Stranger 16	29,41%	63,64%
Stranger 17	76,47%	54,55%
Stranger 18	52,94%	45,45%
	SUM	SUM
	49,18%	54,55%

	Class W/O	Class With
SUM (mean) pre	**49,18 %**	**48,69 %**
SUM (mean) post	**54,55 %**	**68,01 %**

Class with iPad	PRE	POST
Stranger 1	64,71%	100,00%
Stranger 2	52,94%	54,55%
Stranger 3	58,82%	100,00%
Stranger 4	41,18%	63,64%
Stranger 5	70,59%	100,00%
Stranger 6	41,18%	81,82%
Stranger 7	58,82%	54,55%
Stranger 8	52,94%	63,64%
Stranger 9	23,53%	54,55%
Stranger 10	35,29%	90,91%
Stranger 11	17,65%	54,55%
Stranger 12	14,71%	18,18%
Stranger 13	23,53%	54,55%
Stranger 14	64,71%	63,64%
Stranger 15	70,59%	100,00%
Stranger 16	58,82%	54,55%
Stranger 17	100,00%	100,00%
Stranger 18	76,47%	100,00%
Stranger 19	35,29%	36,36%
Stranger 20	23,53%	54,55%
Stranger 21	17,65%	27,27%
Stranger 22	52,94%	72,73%
Stranger 23	47,06%	54,55%
Stranger 24	29,41%	90,91%
Stranger 25	58,82%	63,64%
Stranger 26	100,00%	81,82%
Stranger 27	23,53%	45,45%
	SUM	SUM
	48,69%	68,01%

Table 11. This table shows the two classes to find out how comparable they are before and after the experiment.

What we see is that the two classes have remarkably similar results when it comes to their results before any use of DragonBox. The difference is less than one percent in the general average. The results after these tests are however quite different, with more than 13% of the results separating the two groups.

Some further comparison can be done. Going through the numbers, the largest yet most compact even groups between the two classes, were the pre-results that ranged from 30-55%. This should give an idea as to the students with very similar starting points and how they have progressed. This group is separated by more than the initial difference between all the results, but it was the closest

results from the data. In addition, these groups cannot be divided by use of DragonBox.

30 to 55%			
Without iPad		With iPad	
47,06%	54,55%	41,18%	63,64%
47,06%	36,36%	41,18%	81,82%
35,29%	63,64%	35,29%	90,91%
32,35%	45,45%	35,29%	36,36%
47,06%	63,64%	52,94%	72,73%
47,06%	63,64%	47,06%	54,55%
41,18%	72,73%	52,94%	54,55%
52,94%	45,45%	52,94%	63,64%
43,75%	**55,68%**	**44,85%**	**64,77%**

Table 13. This table compares the two classes from their similar results on test one.

Without iPad			**With iPad**	
Pre	Post		Pre	Post
23,53 %	27,27 %		70,59 %	100,00 %
76,47 %	54,55 %		58,82 %	54,55 %
47,06 %	54,55 %		58,82 %	100,00 %
47,06 %	36,36 %		23,53 %	54,55 %
35,29 %	63,64 %		52,94 %	63,64 %
32,35 %	45,45 %		35,29 %	90,91 %
94,12 %	72,73 %		52,94 %	72,73 %
58,82 %	45,45 %		29,41 %	90,91 %
70,59 %	72,73 %		23,53 %	45,45 %
64,71 %	100,00 %		64,71 %	100,00 %
17,65 %	18,18 %		17,65 %	54,55 %
47,06 %	63,64 %		41,18 %	63,64 %
47,06 %	63,64 %		23,53 %	54,55 %
23,53 %	27,27 %		64,71 %	63,64 %
41,18 %	72,73 %		100,00 %	100,00 %
29,41 %	63,64 %		35,29 %	36,36 %
76,47 %	54,55 %		41,18 %	81,82 %
52,94 %	45,45 %		58,82 %	54,55 %
SUM			SUM	
49,18%	**54,55%**		**47,39%**	**71,21%**

Table 12. This table compares control class and students with two to ten hours of DragonBox use

What we see is that the class with iPads are still ranging quite a bit higher in the results after the use of iPads with around 9% difference, and the average of results pre-experiment are just over one percent. A statistical significance test on these numbers how that the interaction between classes and results give ($F(1, 14) = 0{,}852$, $P > 0{,}05$). In other words, the differences between the results for these classes cannot be seen as statistically significant.

It was also found that these students could be split in one more comparable way. There are 18 students from the control class and 27 in the main class. Luckily, there are 9 students in the groups with 0-1 hour worth of DragonBox use. We can therefor run the comparison test on the frequent users of DragonBox in one class and compare these to the control class. Running a statistical significance test on this data shows us that ($F(1, 34)=7.845$, $P < 0{,}05$). This means that there is a significant difference between them, as seen in Table 10.

5.6 Ethics

The ethical issues experienced are with the control class. Their wish to avoid consent forms was problematic, as younger students under the age of 18 need parental signatures. Therefore, everything was completely anonymous and was not recorded. The consent form for the main class can be found in Appendix # 2

5.7 Discussion of overall findings:

There are findings from three different methods of investigation that will be discussed here. These are observations, interview and the math experiment. The research question explored here is: *When offered parts of the student math curriculum through an application with elements of gamification, will it motivate them and improve learning outcomes?*

Motivation is one of the main aspects desired from implementing gamification. Data from the use of DragonBox showed that students had averaged 2.75 hours of use during the experiment. As the students were given 2x45 minutes to use this application, this shows that most students have gone beyond this and played either at home or brought their own iPads / cell phones to school. From the observations it was clear that the students were immersed in the application and none of the students were seen using any other applications during the time of investigation. In the interviews it was explained that they found the application “good” or better. The feedback from the interviews in regards to the application and enjoyment was in every way positive and there was not a single response that purely disliked the application. A field the observations could not cover was the value the students felt when playing the game. The value of the application was something most students struggled with understanding. They suggested that this is something they should be taught, and wanted more insights to how the application related to algebra so they would be more motivated to spend even more time on this. A student explained that they might not see what they did as mathematics and that might be why it was so well received. One could speculate if explaining the use and purpose of the application would take some of the naivety away or if would motivate them to learn from the application.

Further motivational aspects from this application are in some cases of the interview to be described as variation. Observations show immersion and personalized content by giving students their own artifacts to play and interact with. The immersion aligns well with the motivational goals of gamification. Interviews explained in several cases that variation and "more fun than regular math" were amongst the popular opinions. These replies along with the observation describes well how DragonBox has used elements of gamification successfully in their application to motivate these students. From the interviews it was made rather clear that students wanted to have their own iPads, but that they wanted to be in a social context with other students. The group rooms inspired comparison of results and small competitions, and created an environment where the students could seek aid from fellow students. Some students even tried competing against each other in this game.

Has solving an equation first ever been a goal for students at the age of around 14? There are some factors of social collaboration mixed in with the motivation as well. The observations claimed that seeking out others for a helping hand was common. Comments from the interview show that many of the students asked for or received help with the application. The observation show that the type of help received is often in a student taking the other students iPad and completing the equation for them, rather than explain it. In addition to this, some explained in the interview that they were able to help students who were far better at maths than they were. Most students explained that they want to sit together with other students while playing.
The difficulty of the application and its impact on the students are seen from both observations and interviews. The observations showed that DragonBox was little complex at the beginning, but that it slowly increased in difficulty. The interviews confirmed this and the analysis found many students to describe the game as "easy" or "very easy". The interview also found that students felt the game progressed well with the difficulty, and some students explained it became difficult. It is unsure to which degree this motivated students, but judging from the focus on the stars at the beginning of the game till the focus seen as things progressed, most students were not particularly motivated by this.

Lack of motivation is also seen in this research. The two classes agreed fairly closely on their enjoyment of maths. The students with the iPads during the previous semester had less negative replies about the topic and the words used were also closer to the neutral scale. 7/12 students in the iPad class and 6/12 students in the control class showed that they were not content with the maths classes.
From the observations some students were seen as unmotivated. They gave up expressions of dismay and some carelessness, perhaps boredom. These students were those who had to share the iPads. Further lack of motivation was seen from the other class which had not been given the chance to play DragonBox game during class and had heard about the application, had little to no interest in trying DragonBox. From those who tried it most showed lack of interest and one student even disliked it. The difference was mainly in that the students of the other class would have to play at home during their free time. The price of the application could have something to do with the choice of this, as two students in the DragonBox test class explained the price was the reason they had not bought it. The price was never mentioned however in the class who had not used DragonBox in class. There is to be a limit as to what the students want to do in their spare time. From the DragonBox class, we see that very few of the students have played this application at home often, but some had. Nearly all students from this class explained that they played games on

their iPads and half of them said they had tried educational games. They do not desire playing an educational game like DragonBox at home. It might perhaps be that the application is not "game" enough to be considered a game for those who wish fun and entertainment. In which case, the motivation to play is that it is more fun than normal mathematics.

The experiment shows use of DragonBox and higher improvement in results are statistically significant in some cases, but the data when compared all show that students with higher use of DragonBox have better results. One of the two groups checked had a statistical significant improvement. Both groups with frequent DragonBox use did however show a large average improvement compared to those who did not use the application. The first group, which had proven statistical significance, showed over 25% better improvement than its counterpart. The second group without the proven significance showed 11% better improvement than that of its counterpart. In addition, when compared to the control classes, the students who used DragonBox for two hours had a better result than the control group by 17% which was seen as statistically significant. From the experiment and the research methods used, we gather that there was evidence to support that the null hypothesis is true (*H0=Frequent use of DragonBox on tablet will improve results and motivation in math classes for junior high students*.)

The experiences with math as a subject were seen a little differently by the two classes. If we start with the class who has used DragonBox, observations and interviews has shown a reduction in noise levels. The observations noticed that without a teacher, some students were in the habit of getting loud and impatient. The interviews also confirmed that this could happen. Mostly the students were very quiet and did their own thing. Let us have a closer look at what happened to the classroom situation after this technology was introduced, as it carries disruptive qualities and has completely changed the way their learning was done.
The explanations from the students and from the teacher himself gives a hopefully accurate picture of their maths classes. The teacher himself explained that he would give those who were next in line an iPad and make sure that all students were given two maths classes during this period of time to use DragonBox. When observed, this looked to be the case as those who were picked were the students of the same area of desks - Typically student 6-9 if counted clockwise. In addition to this, he allowed the students who themselves supplied devices to join these if they wanted to. This group of students then remained in the classroom without a teacher. The rest of the students went with him to receive the classical form of learning. This experience was corrected during the interview as the

students explained it normally was the other way around. It was explained during the interview, that this process was done in a manner like this: Students who felt comfortable with the homework and felt they did not need anything explained would be granted access to the iPads that math class. The students who had issues would however stay in the classroom with the teacher and he would go through the mathematics with them. This is something the students were happy with. However, this also means that there has to be one available room for the two groups of students, and most schools are not exactly known for their abundance of available rooms. In addition, there were several questions on how exactly they managed to behave on their own. They explained that it was mostly quiet when they were playing together, though some explained it could be noisy.

One student explained that it was quite noisy some of the time. Experiences with the observations confirm that it could indeed be noisy, but for the most part they behaved quite well. In addition, some students explained during the interviews that some of them were using Facebook and such during this time, which was not made possible by the iPads they were lent, but most likely from 3g internet access.

One aspect that is unexplored but incredibly interesting is the students who received the help from the teacher with more than half the class missing. It is likely that their lectures were more fruitful, but no insights are had on this.

6 Comparing data

The use of the tablets has been very different between the case study and experiment. From the literature review (Peck, Cuban, Kirkpatrick. 2002), we saw that the tablet was mostly used as a supportive technology to automate or simplify certain processes. This supportive role was something we saw again in the case study. Note-taking and web browsing were most commonly mentioned in the literature review, but what we see from the case study is that the applications available in the apple store can also greatly contribute to classes and was one of the most used features in the class. From the experiment, we see a completely different use. In this scenario the iPad was not supportive, but rather the main focus of the class. The use took on a disruptive property as the students went from iPad enhanced chalk and talk classes to a class which was iPad driven. The findings from the case study mostly relied on the iPad improving availability of the curriculum, giving it to your fingertips and allowing the students to manipulate forms and shapes through 3D applications. This method can be seen as a way to advocate hands on learning, liberty and social collaboration, which was promoted by constructivism. The students can find their own way to learn topics through applications, or use the web to find applications for themselves. They could potentially dictate their own learning. Koile, Reider, and Rubin (Koile, Reider, & Rubin, 2010) showed us that sharing of information is reported beneficial and in addition they speak of student led explanations. From the interview in the experiment, we see that student led explanations are preferred by the students who brought up the subject as they can teach the students from a point of view more comparable to theirs.

Social collaboration: From Henderson and Yeow (Henderson & Yeow, 2012), we learned that the smaller devices were better suited for social collaboration. In both case study and experiment, there were a small number of devices available. The solution in the case study was to divide the students in to groups and provide one tablet per group, or to lend the device to the most interested students. This resulted in most use being social. Students would move between desks to show information and findings to other students. The use of iPads would often be directed by one or two students in the groups. This relates well to smaller devices better to facilitate social collaboration (Henderson & Yeow, 2012) due to the mobility we see. The students reported being happy with the device and happy with the use, but the downside was a use limited to certain scenarios and the classes which had to be facilitated for iPad use. In the case study, the device was successfully integrated and reported to improve group work and noise levels.
In the experiment, the use of iPads was more structured, as students followed a queue and were

given two math classes each with the iPad. The social collaboration was however reported vastly different in the experiment. The students reported that they wanted to play together with their fellow students, however, not on the same device. The study by Barendregt and Bekker (Barendregt & Bekker, 2011) showed multiplayer to be something the students were interested in. In the experiment we can see that this is the case as students want to play in a social environment and we see some students compete against each other with the progress and results from levels. There was a clear multiplayer feeling for the students when they played in class, as they sat together and worked. The application however, is not created with any multiplayer functionality. Another social collaboration aspect seen in the experiment was the amount of help students needed and offered. Some students were hesitant to ask, but most students gladly asked and helped. As DragonBox does not time the levels, the students were free to put the devices down and help when someone asked. We see that the social collaboration has been completely different in these cases, but in both scenarios they have been exclusively positively described by the students.

Motivation: Some examples from the literature review show the general attitude from tablets in education. From Sommerich et al. (Sommerich et al, 2007), we learned that student enjoyment of iPad was incredibly high, and that it improved interactions with the teachers. Similar was seen in Koile et al. (Koile, Reider, & Rubin, 2010). From Henderson and Yeow (Henderson & Yeow, 2012), we saw that students felt engaged and empowered by their work on the tablets. From Stickel (Stickel, 2009), we see that 81% of the students felt the tablets improved their education.
There are several aspects which can motivate students. The topic of variation was rarely brought up in the case study, but in the experiment it was mentioned frequently. The students wanted variation. The control class showed us that ten out of twelve students wanted some form of variation to their maths classes. Nearly half of both classes were either neutral or negative towards the math class experience. The interview with the main class explained that DragonBox offered the students some variation and that this was fun. The case study showed that 3D applications to learn the curriculum was often used to empower student learning. In addition, the possible removal of books, and possessing an updated curriculum was often a motivational factor for the tablet.
Interest and coolness of the device is also a motivational factor (Culén & Gasparini, 2012). In the case study we learned that the interest of the iPad was high, as students found the device cool and that there were major issues supplying all the interested students with tablets. The result from the experiment show a positive attitude for all students that used DragonBox in the class, but in contradiction we see from the students who did not use DragonBox in class a complete lack of

interest, but explain that they would be interested if offered in class. Students used an average of 2.9 hours on the application. It took the author of this thesis 44 minutes to play through all levels and bonus levels. From the feedback of difficulty, it is likely that many students have played through the levels more than once. It is unknown why this is, but an article by Lomas, Patel, Forlizzi and Koedinger (Lomas, Patel, Forlizzi & Koedinger, 2013) had some interesting finds which could explain some of this, as they found that: "*...the easier the game, the longer people played*". An alternative explanation is that the students would rather play the game over and over instead of going back to regular maths. Other motivational aspects seen were related to equality, games, immersion, and situation. Equality was seen when a student could help a better student when playing DragonBox. From the artifacts we found that the top two shared educational applications were Heart and King of Maths. The other top shared applications were either games or social. From this we can gain the knowledge that educational games and applications which promote the curriculum in varied ways are seen as interesting to the students. Immersion as a last point is something that is observed in both case study and experiment. It was seen as stronger in the experiment however, as the students did not change the application during class.

Ease of use: The ease of use is promoted in Henderson and Yeow (Henderson & Yeow, 2012), but explained as not all that it seems to be by Culén et al. (Culén, Engen, Gasparini & Herstad, 2011). In the case study we found from several sources that the iPad was an easy device to grasp the basics of. No students were observed asking for help with the device itself, but the teacher reported that the students with a careful approach had an easier time than the students who claimed to know it all. In addition, the teacher explained that he was able to show the students that he knew many things about the device which they did not. All the students in the experiment managed to easily navigate DragonBox, but they explain that the teacher was not good at it. What we see are signals in favour of both research examples, as the basics are easy but that some use require more insight.

Role of gamification: In the literature review, we saw that games were often used more than web browsers by younger students (Henderson & Yeow, 2012). We saw that the maths games were used to teach students the math through repetition, and that it was no different than solving the actual equations (Oleson, Surprenant, Carbone & Blair, 2011). We have seen several positive outcomes from studies, and lastly there are the key points of what gamification can offer education (Saunderson, 2011). Which can be compared to the outcome of the experiment. Games were seen

used on all tablets during the case study and often used during class. 70 out of 110 applications were listed as “fun” and most of these applications were games. Thus, the findings from the artifacts support this notion presented by Henderson and Yeow. Further, the use of math games to improve results was proven in the experiment. As to the key points offered by Saunderson, we have found that DragonBox offers tutorials and immediate feedback to student understanding, pride is seen by students who do not ask for help and by students who help better students than themselves. Learning is adjusted to the students, as they are found to spend their time on different chapters and levels in the application. Students can also work in their own pace, but the role of the teacher as a mentor was not seen in the experiment. The mentor role of the teacher was seen in the case study when judging quality of applications and the use of such. Tracking performance is done through stars and is seen by the students as something they initially are eager to acquire.

Issues with the device: In the literature review we find many issues with the device. Slow finger typing (Wieder, 2011), content creation (Henderson & Yeow, 2012), battery issues (Sommerich et al, 2007), integration of tablet in classes (Sommerich et al, 2007), and the novelty effect (Culén & Gasparini, 2012). Finger typing is looked at briefly as students mention taking notes on the tablet. No notes were found on the tablets. It was not a popular activity and it was completely absent in the experiment despite the students having access to the tablets. This aspect has not been embraced by the students in either research. This point relates to the only connection between content creation and tablet which the students were involved in. Thus, content creation with a tablet was close to absent through the case study and experiment. Battery issues were experienced and reported by some students during the experiment, but it was seen when installing applications for the class, that the iPads were always on low to no battery. Integration of the tablet in the classes was executed differently in case study and experiment. The case study showed some issues with facilitating the classes for the use, due to number of devices and their use purpose. The experiment showed issues with integration in that the class was split in two. It is clear from this that both activities cannot be done at the same time. Integration is thus seen as a difficult aspect of the tablet, but in both scenarios the solutions worked well for the students. The last point, which is the novelty effect, was not seen amongst the students in either study. A point that was not brought forth in the literature review, but that was discovered during the case study, was the monitoring of student activity. The technology is easy to hide and angle away from the teacher. The observation, and interviews confirmed this and that it was often done. A last mentioned issue was bandwidth.

Rich ecology: Henderson and Yeow (Henderson & Yeow, 2012), explained that the tablet is something that should be used in addition to other technologies. As the case study offer such a rich product ecology, it is fair to investigate this further. The students have in both case study and experiment been allowed to bring cell phones, laptops and tablets to class. In the experiment, only iPads and cell phones were used to play DragonBox on. The case study was different, as laptops and cell phones were used along with the iPads. The different use observed on each of these devices show preferences for certain roles. Production aspects are preferred on the laptop, but for any consumption purpose seen, the iPad has been chosen. Cell phones were a last resort and often used for text messages.

What we see from this comparison, is that the data found in the literature review ties closely to the findings in this thesis. There is no ground breaking new discoveries, but the tablet has been confirmed to offer much as a tool for education for students and teachers alike. In addition, gamification has proven a fruitful addition for motivating students and improving results.

7 Discussion

Role and effect of tablet in the classroom: Bromley (Bromley, 1998), gave a clear warning to how a device should be integrated in to a classroom. From this thesis we can see that his predictions mostly came true when the introduction of the device is done from a technologic perspective. The research was defined, but it was an exploratory study to how the technology could and would be used. Thus clear plans to introduction were lacking as several methods were attempted by the teacher. Most of these attempts fell in line with the autonomous predictions by Bromley. However, not all. Recordings of lectures were predicted in his article and the students present were seen as passive observers trying to absorb the knowledge (Bromley, 1998), this was however the students who were seen attending the recorded lecture. From a different angle witnessed in this thesis, the method offers students a possibility to adapt what they learn to their own skills and interests. Some lectures can be superficial and cover very general information, while other can be in depth and offer interested students incredibly insights. This is one of the many possibilities that the tablets and other devices can offer the classes. The second aspect was the applications that allowed manipulations of objects. These applications offer a learning scenario with a focus on hands-on learning. The downside of this is that the technology is very dependent on the created content for the device. In regards to the learning paradigms and Bromley's accusation that some devices can favour some and alienate others, we see that the tablet can support a passive role where the student watches recordings of lectures as promoted by behaviourism, a more active role by seeking answers and the relation between these supported by cognitivism or a more direct learning approach with 3D figures and math equation solving where you learn by playing with the content, which is supported by constructivism. In relation to the difference in learning, Stickel has reached a similar understanding and explains in his article that the tablet pc: *"...does not alienate a particular type of learner."* (Stickel, 2009). In this manner we can understand the iPad as a tool that is not limited to one paradigm, but is open and allows different use. The tablet does in other words have a supportive aspect which can be used to strengthen most classes with online accessibility and the tools it offers for subjects, but also a disruptive property which offers many different forms of learning to the students, which would not have been possible in today's classroom.

Role and effect of gamification in the math classroom: Gamification has been explored in this thesis with grave warnings and high expectations. We have seen that the aspect of gamification can help motivate students to learn maths by presenting the repetitions in different ways. We have seen that there are many students who do not like math and that this is something which improves when

they are allowed to play games and have a varied learning environment. The math subject is perhaps the best example of education that is repeated until learned. In math classes, the students sit with their notebooks and solve equations over and over till they have grasped the correct order and an understanding of different math forms such as algebra. The exact same process is repeated in the math games, where DragonBox is no exception. By creating equations which look different but have the same mechanics, students are more motivated to go through them over and over. On the other side, this game did not have much success with the control class which were not offered to play during class, which raise questions to why this is. Games are proven popular amongst the students, but educational games are not by most students, unless offered in class. The terms hard and soft gamification are likely involved, as the focus in DragonBox is mainly on presenting the content, with added elements of gamification, while the games they prefer are created mostly to be a game. The role of gamification can thus be seen as a way to mediate the content the students learn. When the students are presented with the same type of equations but the resemblance is not obvious they find it easy and fun. When the content starts to resemble the normal equations however, the students have difficulties solving them. Through this we see that gamification presents the content in a way that gives students the opportunity to forget what they dislike and redo the equations till they have the basic order learned without negative feedback of any sort. With this the students can learn the curriculum at their own pace with customized learning to the skill level the students are on. This creates an effect in the classroom where the students are more motivated to learn and immersed in the curriculum instead of killing time.

The information found in this thesis can be important for everyone. School students and the teachers are those immediately affected, but so are the institutions and learning paradigms. Schools have issues with students that lack interest and find the normal chalk and talk method boring and uninspiring. Reading books is not for everyone, yet the system is created so that it is. Sometimes the educational sector has to adapt itself to the needs of the children and meet them half way. In the case study it has been shown clearly that the students love games and that this is mostly what they do on the iPad at home. Why then would the schools expect the tablets to only be used for reading or backing up the old chalk and talk method? It is naïve to think that the teachers do not need to evolve with the rest of the world. On the other hand, it is naïve to expect everything to change. The adaption of the technology plays a key role for the outcome. We saw schools which are at the peak of technology fail to use it for what it was worth and we have seen that many of the limitations are blamed on the teachers. Motivation is a powerful tool for learning and if we manage to motivate

students and teachers alike for this technology, then the tablet device clearly has the possibility to be a disruptive technology and offer many forms of student learning– or create new ones. We can expect the role of the teacher to change from someone who teaches knowledge to facilitating knowledge, but it does not have to. The tablet can be both supportive for the current form of education with its ways to present the curriculum and fundamental for varied learning by offering the learning in ways a book or paper never could. The choice is there.

8 Conclusion & way forward

In this thesis the role and effect of the tablet was investigated in a classroom environment of junior high through a case study. From this an application called DragonBox was discovered and tested through an experiment to find out if the students would be more motivated to learn math and improving their results.

The main role of the iPad was found to function as a supportive technology with the current educational situation and comprehension of the device as the main reasons for this. The device has proven to support many learning styles and to facilitate newer variants of teaching.
The effects of the device is seen to reduce noise levels in classes, in addition to improving and promoting social collaboration. There are further positive effects found as the schools have older books with outdated content. This issue can be corrected through the use of internet, but this media needs a device to function through such as the iPad.
Further, we see that the device had an effect which immersed students in the classes and offered tools for more active classes which were investigated. The tools ranged from calculators to rulebooks in the maths subject, but also included games to help motivate student learning. In natural science, the tools were applications that could help calculate unit measurements and applications which offered 3D representations of their curriculum such as the heart.

DragonBox was tested to see if the students were more motivated to learn and if their results would improve, the students were presented with two tests which were answered before and after the use of DragonBox. A control class was included which took both tests but did not use the iPad. The data was the investigated with the help of statistical significance tools. Results show that in most cases a statistical significant difference was achieved, which proved that in this case, gamification can help the students learn. In addition, motivation for learning was seen in nearly all students, which found this application to be fun, challenging and described by some as better than maths. All students asked in the class of the experiment gave positive feedback on DragonBox and the challenge it provided, but asked questions as to how it related to maths. Motivation to play DragonBox was not found in the control class, but they explained that if they were allowed to play during class, they would be interested.

In both case study and experiment, the information gained was in line with what the literature review offered. The different attempts to teach children in the case study were mostly in line with what has been attempted in the literature review, but some new variants were attempted, such as 3D figures to manipulate objects, which inspired students. Both literature review and experimental research conducted in this thesis has found gamification to improve and motivate learning.

As a result from this research, it is believed that the term gamification lives up to some of its hype. Further, it is hoped that some schools will be more inclined to consider how they could integrate tablet technology in a "Curriculum-driven" (Bromley, 1998) manner, instead of a "technology-driven" (Bromley, 1998) way.

Way forward: The tablet technology has seen much research and has been proven successful for supportive purposes. From the finds in this thesis, it is suggested that further research can be done on the disruptive qualities uncovered. In addition, gamification and all the warning signs that have been presented are still in a phase with little research to investigate the long term effects of this different form of learning, such as the effect on the community driven projects mentioned by Judd(Judd, 2011).

9 References

Apple. (2012): "*Apple in Education – The device that changed everything is now changing the classroom*." Last consulted 30.05.2013. From http://www.apple.com/education/ipad/ [Online]

Antin, Judd: "*Toy psychology: using virtual points and badges to shape our behavior may not be as effective as some have hoped.*" Technology Review (Cambridge, Mass.), Sept-Oct, 2011, Vol.114(5), p.11(1)

Barendregt,Wolmet. Bekker, Tilde M: "*The influence of the level of free-choice learning activities on the use of an educational computer game*" Department of Applied IT, IT University, University of Gothenburg, Department of Industrial Design, Eindhoven University of Technology, Computers & Education 56 (p80–90) 2011.

Baxter, Pamela. Jack, Susan: "*Qualitative case study methodology: study design and implementation for novice researchers*" McMaster University, West Hamilton, Ontario, Canada. The Qualitative Report Volume 13 Number 4 December 2008 544-559

Blomberg, J. Giacomi, J. Mosher A. and Swenton-Wall, P: "*Ethnographic Field Methods and Their Relation to Design"*, In Schuler, D. & A. Namioka (eds.) Participatory Design: Principles and Practices. Hillsdale, N.J.: Erlbaum. Pp. 123-156. 1993

Bromley, Hank. "*What to ask about technology*." Initial Statement for ITForum Discussion, ITForum Paper 29 (1998).

Brown, S.: "*Play as an organizing principle*". In: Bekoff, M., Byers, J.A. (eds.) Animal Play: Evolutionary, Comparative, and Ecological Perspectives, pp. 243–259. Cambridge University Press, Cambridge 1998

Clifford, G. C. (2005): "*Ethics and Politics in Qualitative Research"*. In Denzin, N. & Lincoln, Y. (eds.). The Sage Handbook of Qualitative Research. Sage Publications. 2005. Chap. 6, pp.139-164.

Crang, mike & Cook, Ian: "*Doing Ethnographies*" Sage publications ltd 2007. ISBN: 978-07619-4446-1. 1st

edition.

Culén, Alma; Engen, Bård Ketil; Gasparini, Andrea & Herstad, Jo: "*The Use of iPad in Academic Setting: Ownership Issues in Relation to Technology (Non) Adoption*". Old Meets New: Media in Education – Proceedings of the 61st International Council for Educational Media and the XIII International Symposium on Computers in Education (ICEM&SIIE'2011) Joint Conference. ICEM. 2011

Culén, Alma & Gasparini, Andrea: "*Situated Techno-Cools: factors that contribute to making technology cool in a given context of use*". PsychNology Journal. 2012. ISSN 1720-7525. *10*(2), s 117- 139.

Culén, Alma; Gasparini, Andrea: "*Tweens with the iPad Classroom – Cool but not Really Helpful?*" Inst. of Inf., Univ. of Oslo, Oslo, Norway; e-Learning and e-Technologies in Education (ICEEE), 2012 International Conference on 24-26 Sept. 2012

Culén, Alma & Gasparini, Andrea: "*iPad: A New Classroom Technology? A Report From Two Pilot Studies*" Information Sciences and e-Society. Department of Information Sciences, University of Zagreb. 2011.

Fister, K. Renee; McCarthy, Maeve L.: "*Mathematics instruction and the tablet P*C" Department of Mathematics and Statistics, Murray State University, Murray, KY 42071, USA Version of record first published: 27 Mar 2008.

Forlizzi, J.: "*The Product Ecology: Understanding Social Product Use and Supporting Design Culture*". International Journal of Design, 2(1), 11-20. 2008

Freitas, Sara de. Liarokapis, Fotis: "*Serious Games: A New Paradigm for Education*?" Serious Games and Edutainment Applications 2011, pp 9-23

Gasparini, Andrea. Culén, Alma Leora.: "*Children´s Journey with iPads in the Classroom. // Opportunities and Challenges when Designing and Developing with Kids*" @ School at the Interaction Design for Children Conference (IDC 2011). Ann Arbor, Michigan, 2011

Gorgievski, N. Stroud, R. Truxaw, M. DeFranco, T.: "*Tablet PC: A preliminary report on a tool for teaching calculus*" International Journal for Technology in Mathematics Education, 2005, Vol.12(3), p.95-102

Harpstead, Erik. Myers, Brad A. and Aleven, Vincent.: "*In Search of Learning: Facilitating Data Analaysis in Educational Games*". Human-Computer Interaction Institute, Carnegie Mellon University Pittsburgh, CHI 2013: Changing Perspectives, Paris, France

Henderson, Sarah. Yeow, Jeff: "*iPad in education: A case study of iPad adoption and use in a primary school*" 45th Hawaii International Conference on System Sciences, 2012

Jensen, Matthew; "*Engaging the learner: gamification strives to keep the user's interest: contextual game design must put the player experience first".* T+D, Jan, 2012, Vol.66(1), p.40(5)

Koile, Kimberle, David Reider, and Andee Rubin: "*INK-12: A Pen-based Wireless Classroom Interaction System for K-12*". In The Impact of Tablet PCs and Pen - based Technology on Education: Evidence and Outcomes. Reed, R. and Berque, D. (editors) Purdue University Press, 2010

Kosheleva, Olga. Rusch, Ana. Ioudina, Vera: "*Analysis of effects of tablet PC technology in mathematical education of future teachers*" University of Texas at El Paso, United States 2006

Lazar Jonathan, Feng J. Heidi, Hochheiser harry: "*Research methods in human computer interaction*" London: Wiley; 2010.

Lindström, P. Gulz,A. Haake, M & Sjödén,B: "*Matching and mismatching between the pedagogical design principles of a math game and the actual practices of play*" Department of Design Sciences, Lund University 2010

Loch, B.: "*Tablet technology in first year calculus and linear algebra teaching*". In M. Bulmer, H. MacGillivray, & C. Varsavsky (Eds.), Proceedings of Kingfisher Delta '05, Fifth Southern Hemisphere Conference on Undergraduate Mathematics and Statistics Teaching and *Learning* (231-237). Brisbane: University of Queensland. 2005.

Loch, B. & Donovan, D.: "*Progressive Teaching of Mathematics with Tablet Technology*" e-Journal of Instructional Science and Technology, 9(2). 2006

Lomas, Derek. Patel, Kishan. Forlizzi, Jodi L. Koedinger, Kenneth R.: "*Optimizing Challenge in an Educational Game Using Large-Scale Design Experiments*", Human Computer Interaction Institute Carnegie Mellon University, Dhirubhai Ambani Institute of Information and communication Technology (DAIICT), CHI 2013: Changing Perspectives, Paris, France

Lung, Chun Fei: "*Serious games (sometimes) considered harmful (?)*" Faculteit der Exacte Wetenschappen / Vrije Universiteit Amsterdam October 10, 2012

Meloni, Wanda & Gruener, Wolfgang: "*Gamification in 2012*" M2 Research (2012) [Online] http://gamingbusinessreview.com/wp-content/uploads/2012/05/Gamification-in-2012-M2R3.pdf Last consulted: 30.05.2013

Millinder, S.: "*Positive Impact of a Tablet PC-Based Learning Environment on Student-Perceived Learning Outcomes*". First International Workshop on Pen-Based Learning Technologies, May 2007

Muntean, Cristina Ioana: "*Raising engagement in e-learning through gamification*" The 6th International Conference on Virtual Learning ICVL 2011

Nardi, B. A., & O'Day, V. L.: "*Information ecologies: using technology with heart*." Cambridge, MA: MIT Press. 1999

Oleson, Kristin E. Surprenant,Amanda M. Carbone, Tom; and Blair, Lucas: "*Teaching Algebraic Concepts via Serious Games on a Tablet PC*" Proceedings of the Human Factors and Ergonomics Society Annual Meeting 2011 55: 1511

Patton, M.: "*Qualitative evaluation and research methods*" (2nd ed.). Newbury Park, CA: Sage. 1990

Peck, Craig. Cuban, Larry and Kirkpatrick, Heather: "T*echno-Promoter Dreams, Student Realities*" The Phi

Delta Kappan, Vol. 83, No. 6 (Feb., 2002), pp. 472-480

Piaget, Jean: "*To understand is to invent: the future of education*" New York: Grossman 1973.

Polycarpoua, Irene. Krausea, Julie. Radera,Cyndi. Kembela, Chad. Pouporea, Christopher. Chiu, Eric.: "*Math-City: an educational game for K-12 mathematics*" a Mathematical and Computer Sciences, Colorado School of Mines, Golden, United States Procedia Social and Behavioral Sciences 9 (2010) 845–850 WCLTA 2010

Saunderson, Roy; "*Making learning fun: gamification utilizes the experience of fun, along with intrinsic motivation and rewards, to engage and captivate individual learners*". Training, Nov-Dec, 2011, Vol.48(6), p.70(2)

Sheldon, Lee: "*The Multiplayer Classroom: Designing Coursework As a Game*", Course Technology/Cengage Learning, 2011 ISBN: 1435458443, 9781435458444

Silva, André Constantino. Rocha, Heloisa Vieira: "*Experiences in use Tablet PC to Support Student's Activities: Five years of an Exploratory Study*". eLmL 2012 : The Fourth International Conference on Mobile, Hybrid, and On-Line Learning.

Sommerich, C. M. Ward, R. Sikdar, K. Payne, J. & Herman, L.: "*A survey of high school students with ubiquitous access to tablet Pcs*". Department of Industrial, Welding & Systems Engineering, 210 Baker Systems, The Ohio State University, Columbus 2007.

Stickel, M.; "*Impact of lecturing with the tablet PC on students of different learning styles*". 2009 39th IEEE Frontiers in Education Conference, Oct. 2009, pp.1-6

Tellis, Winston: "*Application of a Case Study Methodology*" The Qualitative Report, Volume 3, Number 3, September, 1997 (http://www.nova.edu/ssss/QR/QR3-3/tellis2.html) Last consulted: 11.04.2013 [Online]

Vosniadou, S.: "*How Children Learn",* Educational Practices Series, 7, The International Academy of

Education (IAE) and the International Bureau of Education (UNESCO) 2001

Wieder, Ben: "*iPads for College Classrooms? Not So Fast, Some Professors Say. Rival tablet PC's foster more interactivity, studies suggest. But students' craving for the Apple devices could matter more*"
The Chronicle of Higher Education, March 13, 2011, Vol.57(28)

Yin, R. K.: "*Case study research: Design and methods"* (3rd ed.). Thousand Oaks, CA: Sage. 2003.

10 Appendices

10.1 Appendix # 1: Consent form for case study participation.

Samtykke for deltakelse i studien:

"iPad som supplerende verktøy i undervisningen"

Formålet med dette dokumentet er å få samtykke fra foreldrene til ungdom påvirket av denne studien.

Forskningsprosjektet blir utført av masterstudent Andreas Bergli Sætre ved Institutt for informatikk (UiO). Målet er å se hvordan iPad, som et supplerende læreverktøy, vil kunne bli brukt i undervisningen.

Informasjon om studien:
Ungdommene vil bli bedt om å gjøre noen oppgaver relevante for undervisningen (for eksempel lese bøker og gjøre oppgaver) med dette verktøyet i denne perioden. Mens de utfører oppgavene, vil Andreas, i samarbeid med Reidar Bjørnlid, observere bruken av iPad i noen av skoletimene og stille dem spørsmål vedrørende dette.

Ungdommene vil ha tilgang til 5 iPads resten av semesteret i Reidar Bjørnlid sine timer.

Deltakelse er helt frivillig og deltagere kan trekke seg fra studien når som helst, uten nærmere forklaring. Svar på spørsmål fra ett eller flere intervjuer med ungdommene, samt observasjoner vil bli nedtegnet. I tillegg ønsker jeg å ta noen bilder (eventuelt video) av ungdommene mens de bruker iPad. Nedenfor kan dere krysse av:

- ☐ Ikke bilde
- ☐ Bilde uten ansikt
- ☐ Bilde med ansikt dekket
- ☐ Bilde med ansikt

Eventuelle data som er samlet i studien vil forbli fullstendig konfidensielle. Ingen navn vil bli publisert. Undersøkelsen vil foregå fra ca 12. mars og ikke lenger enn 22. juni.

Underskrift foreldre/forsørger: **ungdommens navn:**

Prosjektansvarlige:
Andreas Bergli Sætre

Dato: 08.03.2012 **Telefon: 98889886**

10.2 Appendix # 2: Consent form for experimental research participation.

Samtykke for deltakelse i studien:

"iPad og læring med spill applikasjoner for matematikk"

Formålet med dette dokumentet er å få samtykke fra foreldrene til ungdom som skal delta i prosjektet

Forskningsprosjektet blir utført av masterstudent Andreas Bergli Sætre ved Institutt for informatikk (UiO), under veiledning av Alma Culén i forbindelsen med masteroppgaven som har innføring av ipad i læringsmiljø som hoved tema.

Informasjon om studien: I det prosjektet som skal gjennomføres med deres barn, er oppgaven å forsøke å måle læringseffekten gjennom spill, i dette tilfelle DragonBox, et spill for å lære algebra. Denne klasses skal bruke ipad for å lære noe av matematik-pensumet gjennom spill. Andreas og klasselærer skal tilrettelegge arbeid med ipadene og observere hvordan studentene lærer med dette verktøyet. Prosjektet vil pågå en måned. Det vil i slutten av denne perioden bli laget en prøve for pensum som blir dekket av denne applikasjonen, som anonymt sammenlignes med en annen klasse på samme trinn.

Ungdommene vil ha tilgang til 5 iPads i en måned - i Reidar Bjørnlid sine timer.
Deltakelse er helt frivillig og deltagere kan trekke seg fra studien når som helst, uten nærmere forklaring. Svar på spørsmål fra ett eller flere intervjuer med ungdommene, samt observasjoner vil bli nedtegnet. Eventuelle data som er samlet i studien vil forbli fullstendig konfidensielle. Ingen navn vil bli publisert. Undersøkelsen vil foregå fra 8 oktober og ikke lenger enn til 9. november. Skjemaet har ikke blitt sendt ut før nå, fordi det ikke har vært noe forskning hittil i perioden, og elevene har hatt fri tilgang til læremiddelet i undervisningen. Nå er det derimot på tide med litt observasjoner og etterhvert et kort intervju med noen av studentene. *Håper ikke dette medfører noen problemer!*

Underskrift foreldre/forsørger: ungdommens navn:

Prosjektansvarlige:
Andreas Bergli Sætre

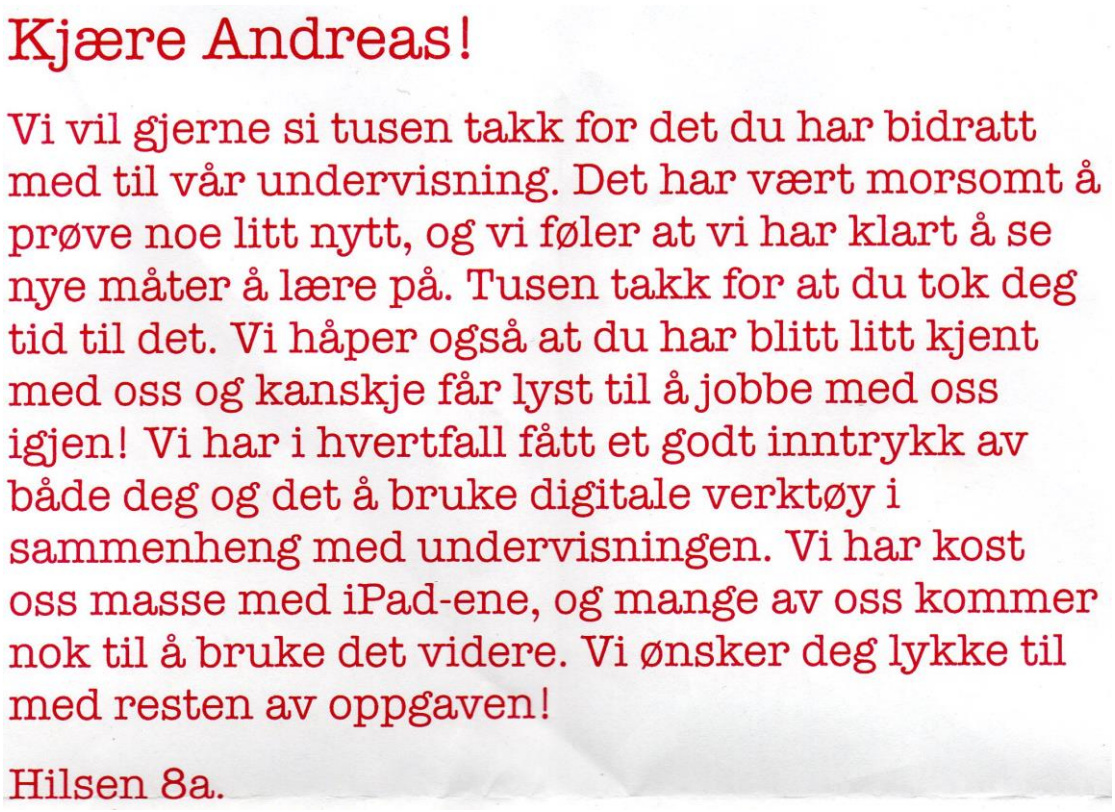
Dato: 24.10.2012
Telefon: 98889886

Informasjon om DragonBox:

http://dragonboxapp.com/
http://www.aftenposten.no/webtv/Larer-algebra-med-app-6827001.html

P.S. Tusen takk for at dere var med på den forrige undersøkelsen. Denne delen er basert på feedbacken dere har gitt meg! Elevene har vært kjempe greie og hyggelige, Hilsen Andreas.

10.3 Appendix # 3: Letter received from students, after the case study was completed.



Kjære Andreas!

Vi vil gjerne si tusen takk for det du har bidratt med til vår undervisning. Det har vært morsomt å prøve noe litt nytt, og vi føler at vi har klart å se nye måter å lære på. Tusen takk for at du tok deg tid til det. Vi håper også at du har blitt litt kjent med oss og kanskje får lyst til å jobbe med oss igjen! Vi har i hvertfall fått et godt inntrykk av både deg og det å bruke digitale verktøy i sammenheng med undervisningen. Vi har kost oss masse med iPad-ene, og mange av oss kommer nok til å bruke det videre. Vi ønsker deg lykke til med resten av oppgaven!

Hilsen 8a.

10.4 Appendix # 4: The post-exposure to DragonBox math test.

Skriv direkte på arket!

OPPGAVE 1

3p Løs likningene:

a) $x + 5 = 7$

$x = 7 - 5$

$x = 2$

b) $3x = 12$

$\frac{3x}{3} = \frac{12}{3}$

$x = 4$

c) $\frac{x}{5} = 4$

$x = 20$

OPPGAVE 2 **2 p**

a Løs likningen: $5x - 2 + 3x = x - 16$

$5x + 3x - 2 = x - 16$

$\frac{7x}{7} = \frac{-14}{7}$

$x = -2$

b Sett prøve på likningen i a):

$5 \cdot -2 - 2 + 3 \cdot -2 = -2 - 16$

$-10 - 2 - 6 = -2 - 16$

$-18 = -18$

OPPGAVE 2 6 p

1 p **a**
Løs likningen.

$x - 2 = 4 - x$

$x + x = 2 + 4$

$\frac{2x}{2} = \frac{6}{2}$

$x = 3$

2 p **b**
Løs likningen.

$25x - 10(3x + 6) = 7x$

$25x - 30x - 60 = 7x$

$25x - 30x - 7x = 60$

$-12x = 60$

$\frac{-12x}{-12} = \frac{60}{-12}$

3 p **c**

Løs likningen.

$$\frac{1-2x}{3}+\frac{5x}{6}=2-\frac{3(1+x)}{2}$$

$\frac{x}{3}+\frac{5x}{6}=2-\frac{3+3x}{2}$

$\frac{x\cdot 4}{3\cdot 4}+\frac{5x}{6\cdot 2}=\frac{4x}{12}+\frac{10x}{12}$

$=$

$2(1-2x)+5x=12-9(1+$

$2-4x+5x=12-9-$

$2-12+9=4x-5x-9x$

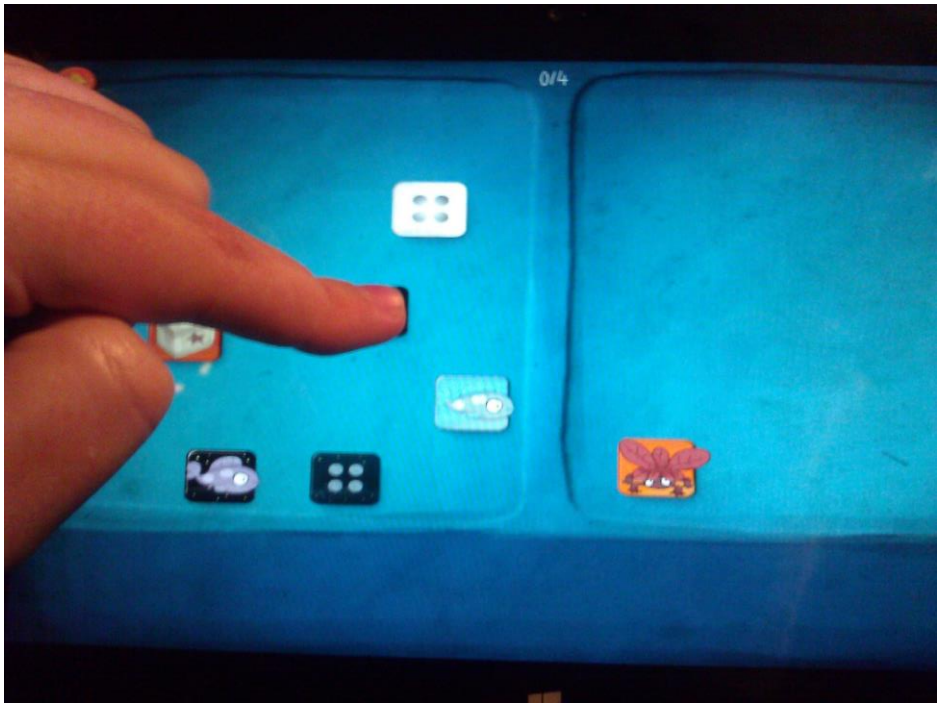
$\frac{-1}{10}=\frac{-10x}{10}$

$x=\frac{1}{10}$

Jeg har totalt spilt Dragon Box i ca (kryss av) timer.

Ingen timer: ☐ ca 1 t ☐ ca 2 t ☐ ca 3 t ☒ ca 5 t ☐ mer enn 10 t ☐

10.5 Appendix # 5: Picture of interaction with DragonBox



10.6 Appendix # 6: Picture of teacher's iPad